

One Journey to Better
Multiple-Choice Testing, or

How do I know if my items are doing
what I want them to do?

CETA Workshop

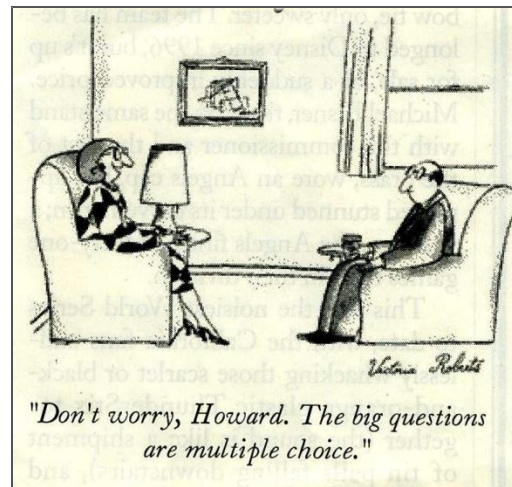
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Motivation

The start of the saga:

- Ted's workshop on multiple choice exams
- Mark works to improve exams for EES 100
- Mark discovers statistics that he does not use (or know how to use)



Ted's workshop in 5 minutes

reasonable aspirations for multiple-choice items

- factual knowledge (Bloom's *remembering*)
- beyond mere factual knowledge (*understanding, applying, analyzing*)

words to the wise

“Writing items is very difficult.”

“A fundamental assumption in writing any test item is that we know what we are testing.”

“Although you may write incredibly good items, your students will fail miserably and suffer if they have *not* received appropriate instruction.”

(Source: Haladyna, T. M. (1997). *Writing Test Items to Evaluate Higher Order Thinking*. Boston: Allyn & Bacon.)

“item analysis”

construct for each item:

Option ↓	UPPER GROUP	LOWER GROUP
1.	5%	23%
2.		14%
(3.)	95%	50%
4.		13%

within each cell:

- percentage of students in the group selecting that option
- or number of students, if small group of scores

two basic “item parameters”

- difficulty
 - the proportion of all students selecting correct option (including middle group)
- discrimination
 - proportion of upper group selecting correct option minus proportion of lower group selecting correct option

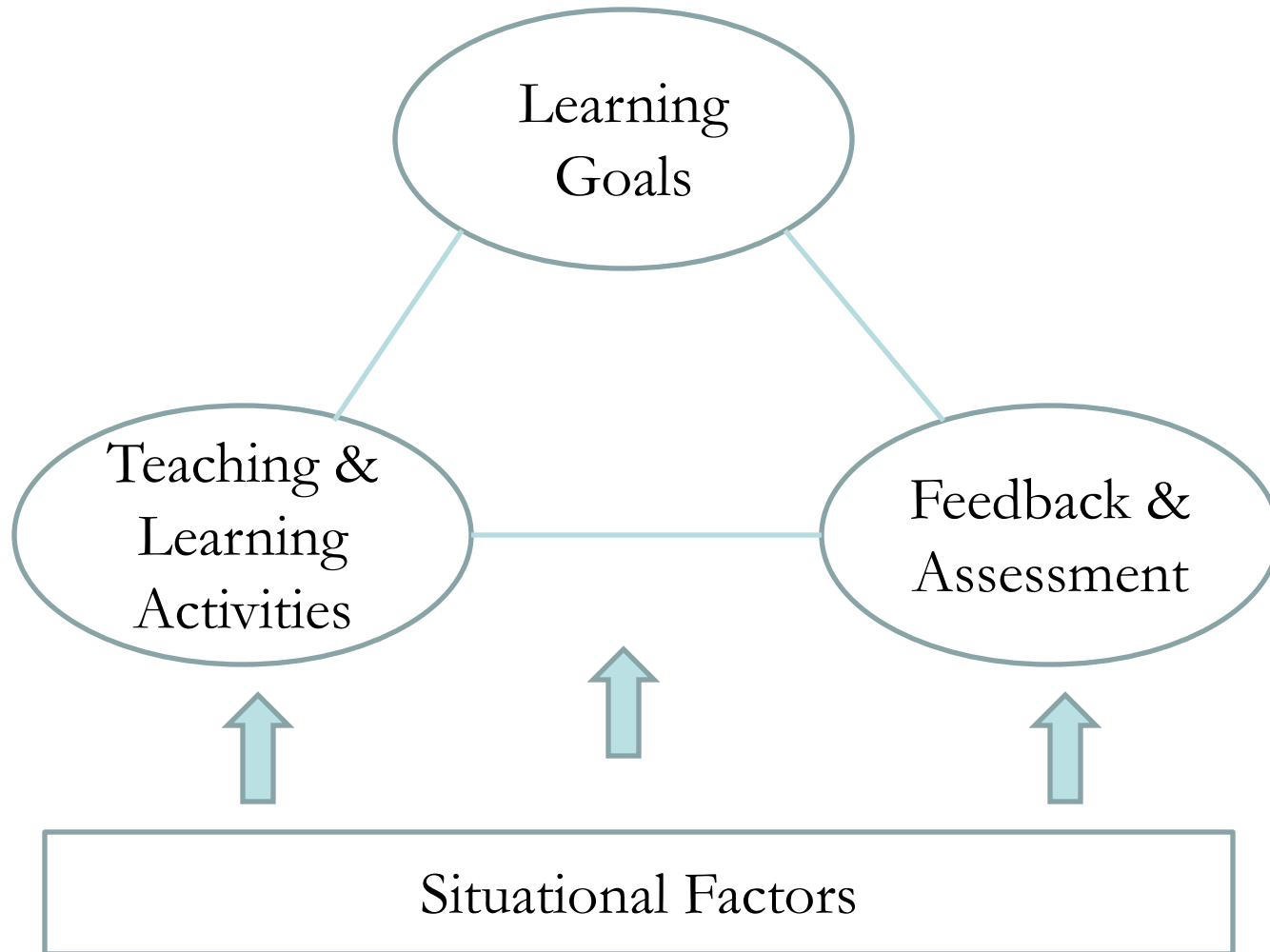
e.g., $.95 - .50 = +.45$

Always consider item discrimination and item difficulty in view of:

- the intended cognitive demand of the item
- how you defined the upper and lower groups (for discrimination)
- the magnitude of score variance
- your assumptions about instructional validity

back to Mark...

The Basic Elements of Instructional Design



From Testing Scoring Services

Mean: 26.7

Median: 27

Mode: 24

Lowest score: 8

Highest score: 38

Standard deviation: 6.7

Number of respondents: 110

Number of questions: 40

Cronbach's alpha: .85

- Ted on the formula for Cronbach's alpha (α):

$$\alpha = \underbrace{\left(\frac{k}{k-1} \right)}_{\text{a minor adjustment}} \underbrace{\left(1 - \frac{\sum \sigma_i^2}{\sigma_X^2} \right)}_{\text{the heart of it}}$$

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$$\alpha = \left(\frac{k}{k-1} \right) \left(1 - \frac{\sum \sigma_i^2}{\sum \sigma_i^2 + 2 \sum \sigma_{ij}} \right)$$

item variance

- formula for Cronbach's alpha (α):

$$\alpha = \underbrace{\left(\frac{k}{k-1} \right)}_{\text{a minor adjustment}} \underbrace{\left(1 - \frac{\sum \sigma_i^2}{\sigma_X^2} \right)}_{\text{the heart of it}}$$

$$\alpha = \left(\frac{k}{k-1} \right) \left(1 - \frac{\sum \sigma_i^2 + 2 \sum \sigma_{ij}}{\sum \sigma_i^2 + 2 \sum \sigma_{ij}} \right)$$

item covariance

Consider this item:

Consumption overpopulation is...

- A. A description of the mechanism for achieving the demographic transition in LDCs.
- B. A conceptual device for thinking about natural resource and environmental effects typically associated with economic growth in richer and more developed countries (MDCs) of the world.
- C. The means of measuring matter/energy throughput in terrestrial ecosystems.
- D. A conceptual device for thinking about natural resource and environmental effects typically associated with rapid population growth in poorer and less developed countries (LDCs) of the world.

An effective question?

Option	Upper third	Lower third	Total	%	Discrimination	Difficulty
A	0	2	3	3	-0.1	
(B)	34	19	81	74	+0.4	.74
C	0	2	3	3	-0.1	
D	0	13	22	20	-0.4	

Problematic Question?

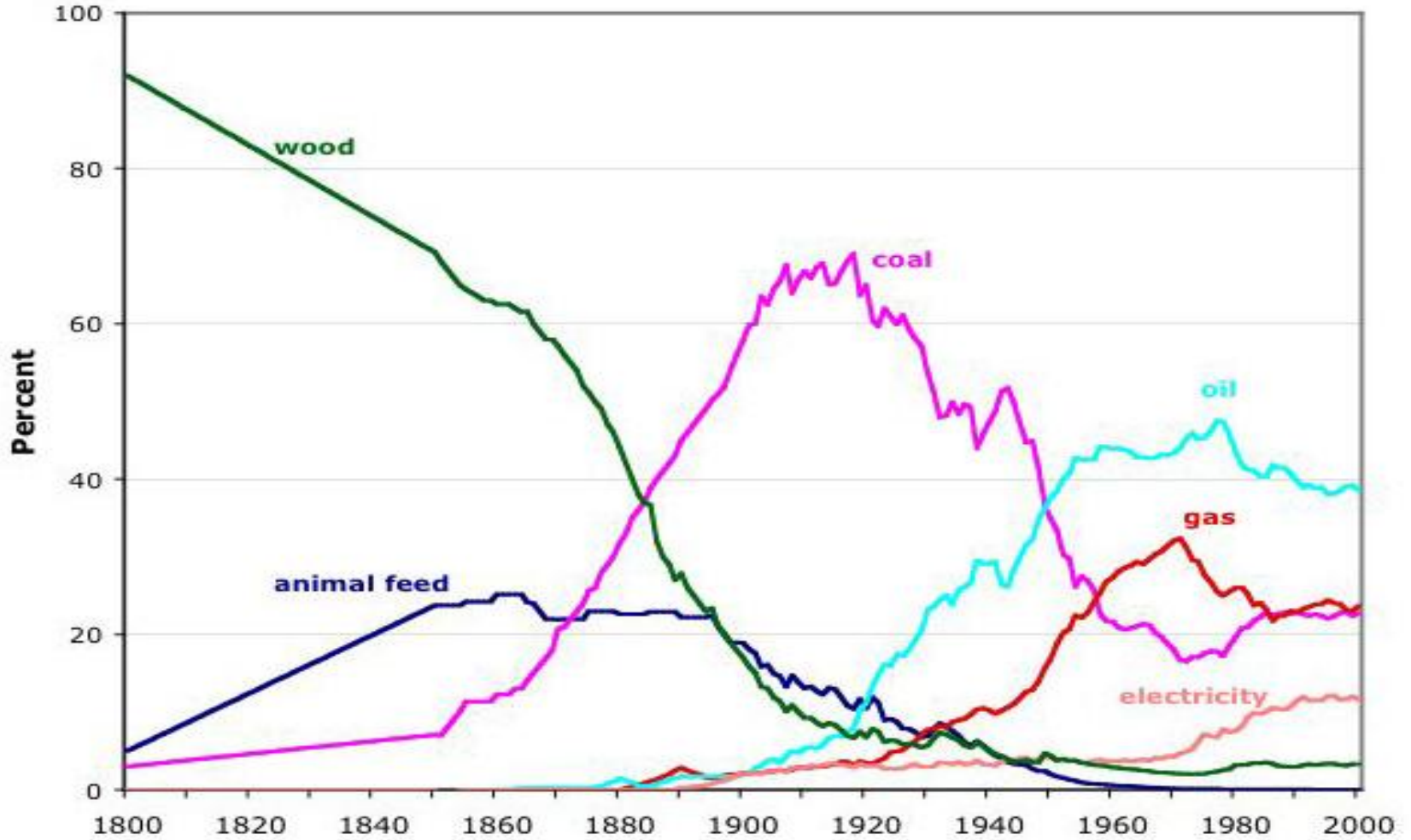
Given the stocks and flows of matter and energy, it is generally most appropriate to think of the Earth as...

- A. An isolated system.
- B. A system where matter and energy are both created and destroyed by human actions.
- C. A system where low entropy energy exits and high entropy energy enters.
- D. A system where high entropy energy exits and low entropy energy enters.
- E. A system where, as matter is consumed or recycled, it exits into the larger universe system causing resource scarcity.

Is it the question or the pedagogy?

Option	Upper third	Lower third	Total	%	Discrimination	Difficulty
A	9	13	30	27	-0.1	
B	3	6	9	8	-0.1	
C	5	9	31	28	-0.1	
(D)	13	4	23	21	+0.3	.21
E	3	8	18	16	-0.2	

Another Problem



This is a depiction of the composition of energy sources for the U.S. economy over time. If the sum of wood and animal feed represents new products of photosynthesis, at approximately what year in U.S. history does use of fossil fuels (old products of photosynthesis) exceed the use of new products of photosynthesis?

- A. 1850
- B. 1880
- C. 1900
- D. 1950
- E. 1975

Option	Upper third	Lower third	Total	%	Discrimination	Difficulty
A	1	4	8	7	-0.1	
B	11	15	41	37	-0.1	
(C)	17	8	40	36	+0.3	.36
D	3	9	18	16	-0.2	
E	1	4	5	4	-0.1	

Review and retest on final...

Option	Upper third	Lower third	Total	%	Discrimination	Difficulty
A	0	0	1	1	+0.0	
B	1	4	7	7	-0.1	
(C)	21	9	42	42	+0.4	.42
D	10	17	42	42	-0.2	
E	1	4	7	7	-0.1	

Example from Ted's past

Option	Upper third	Lower third	Total	%	Discrimination	Difficulty
(A)	12	4	24	36	+0.4	.36
B	3	5	12	18	-0.1	
C	0	3	4	6	-0.1	
D	7	11	27	40	-0.2	

Same item, next semester

Option	Upper third	Lower third	Total	%	Discrimination	Difficulty
(A)	19	5	34	51	+0.6	.51
B	2	6	11	16	-0.2	
C	1	4	10	15	-0.1	
D	1	7	12	18	-0.3	

“It matters not how many distractors one produces
for any given multiple-choice item,
but it does matter if each distractor is working.”

(Haladyna, 1997)

Oh, and your key was wrong...

Option	Upper third	Lower third	Total	%	Discrimination	Difficulty
A	2	3	10	9	-0.0	
B	1	1	3	3	+0.0	
C	1	4	8	7	-0.1	
D	27	22	76	69	+0.1	
(E)	3	6	13	12	-0.1	.12

Unreasonable question?

Chloroflourocarbons are particularly destructive compounds in the atmosphere because they...

- A. Are tropospheric ozone precursors and contribute to the destruction of stratospheric ozone.
- B. Are stratospheric ozone precursors and contribute to the destruction of tropospheric ozone.
- C. Are stratospheric ozone precursors and act as greenhouse gases before they rise into the stratosphere.
- D. Contribute to the destruction of stratospheric ozone and act as greenhouse gases before they rise into the stratosphere.
- E. Are tropospheric ozone precursors and act as greenhouse gases before they rise into the stratosphere.

Option	Upper third	Lower third	Total	%	Discrimination	Difficulty
A	9	9	32	30	+0.0	
B	0	9	13	12	-0.3	
C	1	3	5	5	-0.1	
(D)	20	10	46	43	+0.3	.43
E	3	7	12	11	-0.1	