Diagnostic Model Score Reporting and Use

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Talk Overview

- Types of examinee estimates found in DCMs
  - Probability of mastery
- How examinee estimates are derived
  - Diagnostic rules
- Examples of score reporting from diagnostic models
- Potential use of diagnostic model score reports

EXAMINEE ESTIMATES FROM DIAGNOSTIC MODELS

Nature of Examinee Estimates in DCMs

- DCMs use categorical latent variables (attributes) to characterize examinee ability
  - Models discussed today have two levels
    - Mastery/Non-mastery
- DCMs are latent class models
  - Each latent class is a unique attribute pattern

Examinee Estimates

- Examinee estimates are based on the latent class model parameters
  - Each examinee receives a probability they have each latent class
    - Called posterior probability
    - Analog of θ in IRT (which is typically the posterior mean)
- Attribute pattern estimates can be converted into marginal attribute probabilities
  - More easily understood

LCDM Examinee Parameters

Class:	1	2	3	4	5	6	7	8
Attribute 1	0	0	0	0	1	1	1	1
Attribute 2	0	0	1	1	0	0	1	1
Attribute 3	0	1	0	1	0	1	0	1

Attribute ***Pattern*** Probability Estimates (from Mplus)

Marginal Attribute Probability Estimates (computed in SAS)

ID	cprob1	cprob2	cprob3	cprob4	cprob5	cprob6	cprob7	cprob8	class	prob_attribute1	prob_attribute2	prob_attribute3
1	0.30092	0.51731	0.01615	0.00314	0.08343	0.0785	0.0005	0.00007	2	0.1625	0.01986	0.59902
2	0.8759	0.03581	0.04702	0.00022	0.04058	0.00023	0.00024	0	1	0.04105	0.04748	0.03626
3	0.48186	0.14762	0.1659	0.00574	0.17287	0.00727	0.01863	0.00011	1	0.19888	0.19038	0.16074
4	0.8759	0.03581	0.04702	0.00022	0.04058	0.00023	0.00024	0	1	0.04105	0.04748	0.03626
5	0.02957	0.41591	0.01364	0.06569	0.05328	0.41018	0.00274	0.009	2	0.4752	0.09107	0.90078
6	0.00001	0.00067	0.00117	0.11808	0.00015	0.01984	0.02094	0.83914	8	0.88007	0.97933	0.97773
7	0.00001	0.0001	0.0013	0.01752	0.00112	0.01914	0.15136	0.80945	8	0.98107	0.97962	0.84621

DIAGNOSTIC RULES

Rules DCMs Use for Diagnoses

- In DCMs, people receive diagnoses based on a set of diagnostic rules

- The diagnostic rules can be developed in two differing ways:

  1. Rules based on empirical evidence
  2. Rules based on a blend of expert judgment and statistical analysis

Where Diagnostic Rules are Applied

- Diagnostic rules apply to two types of information:
  1. Item or variable information
     - Helps determine which items are better at discriminating between respondents with differing attribute levels

  2. Respondent information or proportion of respondents with different diagnoses in the population
     - Population-level information
       – Describe the frequency which a diagnosis occurs
     - Is the base-rate for each attribute and association of all attributes

Diagnostic Rules Based on Empirical Evidence

- The item parameters provide information about how well the items discriminate between respondents with different diagnostic profiles

- The population parameters provide information as to the distributional characteristics of the categorical latent variables including
  - For each attribute, a base-rate
  - For all pairs of attributes, an index of association

Rules Based on Expert Judgment

- The technical term for the family of approaches that incorporate these types of information is *standard-setting*

- A diagnostic standard-setting process is one where a group of experts sets:

  – What the expected behavior of respondents with different mastery profiles is for each item with respect to a set of diagnostic criteria

  – What the population base-rates and associations are for each of the criteria

TECHNICAL DETAILS

Attribute Pattern Probabilities

- The formula for examinee attribute pattern probabilities is:

Model Structural Parameter Link: Population Information

$$\boldsymbol{\alpha}_i = \frac{\boxed{\nu_c}\prod_{j=1}^{J}\pi_{jc}^{x_{ij}}\left(1-\boxed{\pi_{jc}}\right)^{1-x_{ij}}}{\sum_{c=1}^{C}\nu_c\prod_{j=1}^{J}\pi_{jc}^{x_{ij}}\left(1-\pi_{jc}\right)^{1-x_{ij}}}$$

Model Item Parameter Link: Item Information

SCORE REPORTING

DCM Scoring and Score Reporting

Diagnostic Scoring Report

Student Name: Daphne

Review Your Answers

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Your Answer	✓	✓	✓	✓	a	c	✓	c	d	✓	✓	✓	c	✓	d	a	✓	b	a	a	d	c	b	a	c
Correct Answer	d	a	b	d	d	a	b	d	a	c	a	b	d	c	a	d	a	c	b	d	a	a	a	d	b
Difficulty	e	e	m	m	m	m	h	h	h	m	e	e	m	m	m	h	m	m	h	h	h	h	h	h	h

Score

You correctly answered 10 out of 25 questions.

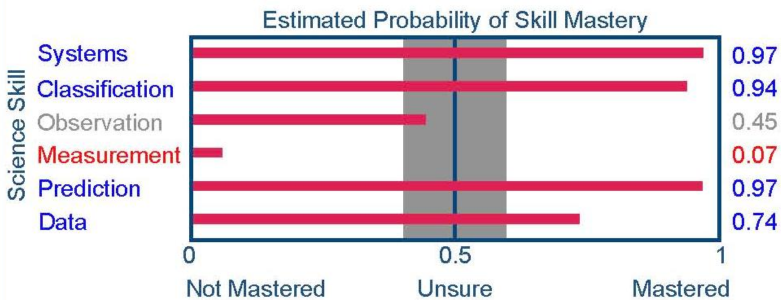
Easy: 4/4; Medium: 5/10; Hard: 1/11

Guide

✓ - Correct answer; o - Omitted answer

e - Easy; m - Medium; h - Hard

Improve Your Skills



Example Questions
3, 14, 2, 17, 19, 23, 9
3, 12, 13, 5, 2, 17, 18, 16, 24, 7
11, 15, 1, 8, 18
22, 20, 10, 11, 5, 6, 18, 25
4, 14, 20, 12, 5, 19, 9
22, 1, 19, 21

POTENTIAL USES OF DIAGNOSTIC MODEL EXAMINEE ESTIMATES

Hypothetical Example

- To demonstrate what can be done with examinee estimates, we present a hypothetical example
- Imagine a benchmark test was given in the middle of a semester
- Examinees and teachers received DCM estimates
  - Used these to characterize

Descriptive Statistics of Attribute Patterns

- To introduce the following slides, the first bit of information we present are the basic descriptive statistics
  - How we would expect an examinee with a given attribute pattern to perform on the EOC test

Skill Pattern	Expected Score
[00000]	22.9
[00001]	26.0
[00011]	29.3
[00111]	31.4
[01111]	34.8
[11111]	41.9

Gain by Mastery of Each Attribute

- The difference in test score between masters and non-masters of an attribute can be quantified

Skill	Gain in Score	Ability Correlation
1	2.61	0.81
2	2.50	0.81
3	1.15	0.63
4	1.19	0.63
5	0.75	0.45

- No correlation between benchmark and EOC:
  - No expected increase in EOC score by mastery of attribute
- Higher the correlation, higher the gain

Pathways to Proficiency

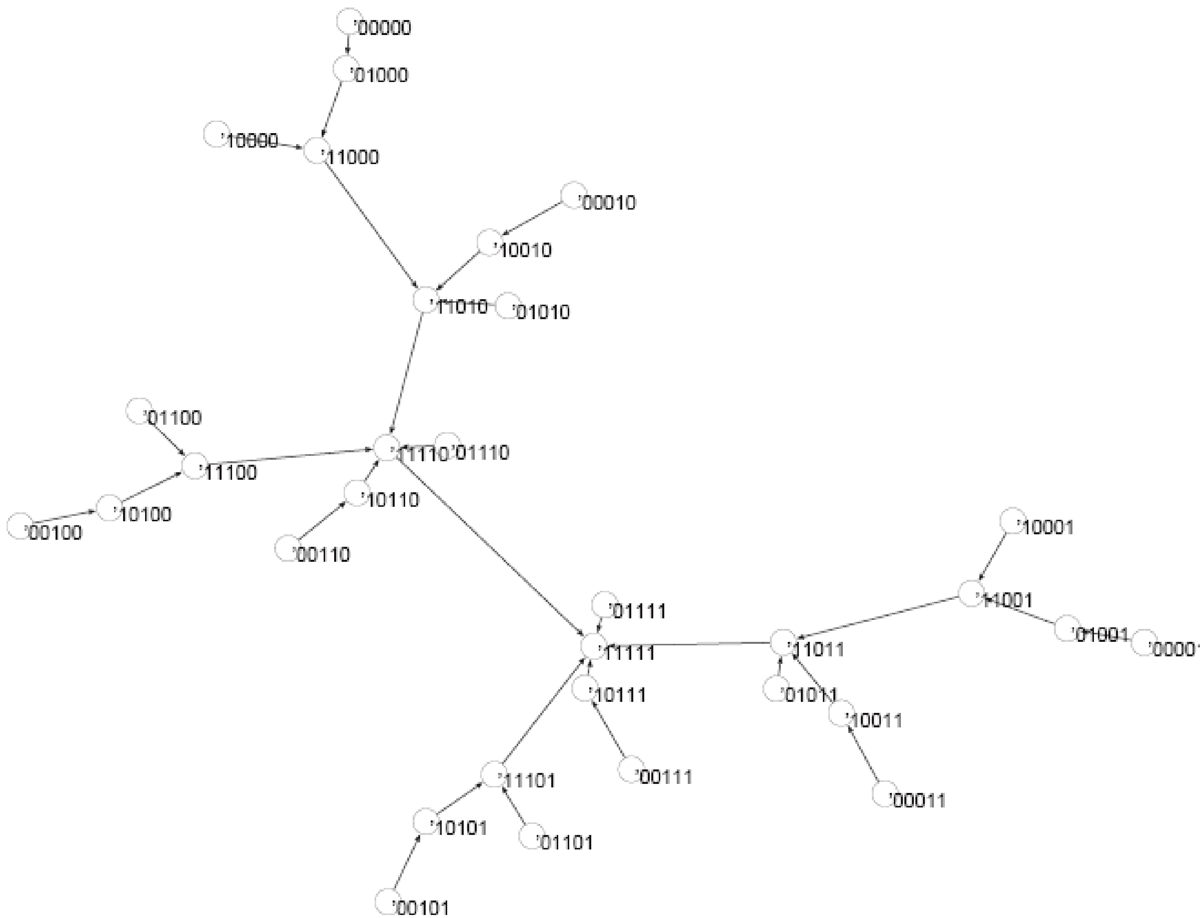
- But perhaps the most important information is in the form of a path a student can follow that would most quickly lead to proficiency on the EOC test

- The pathway tells the student and the teacher the sequence of attributes to learn next that will provide the biggest increase in test score

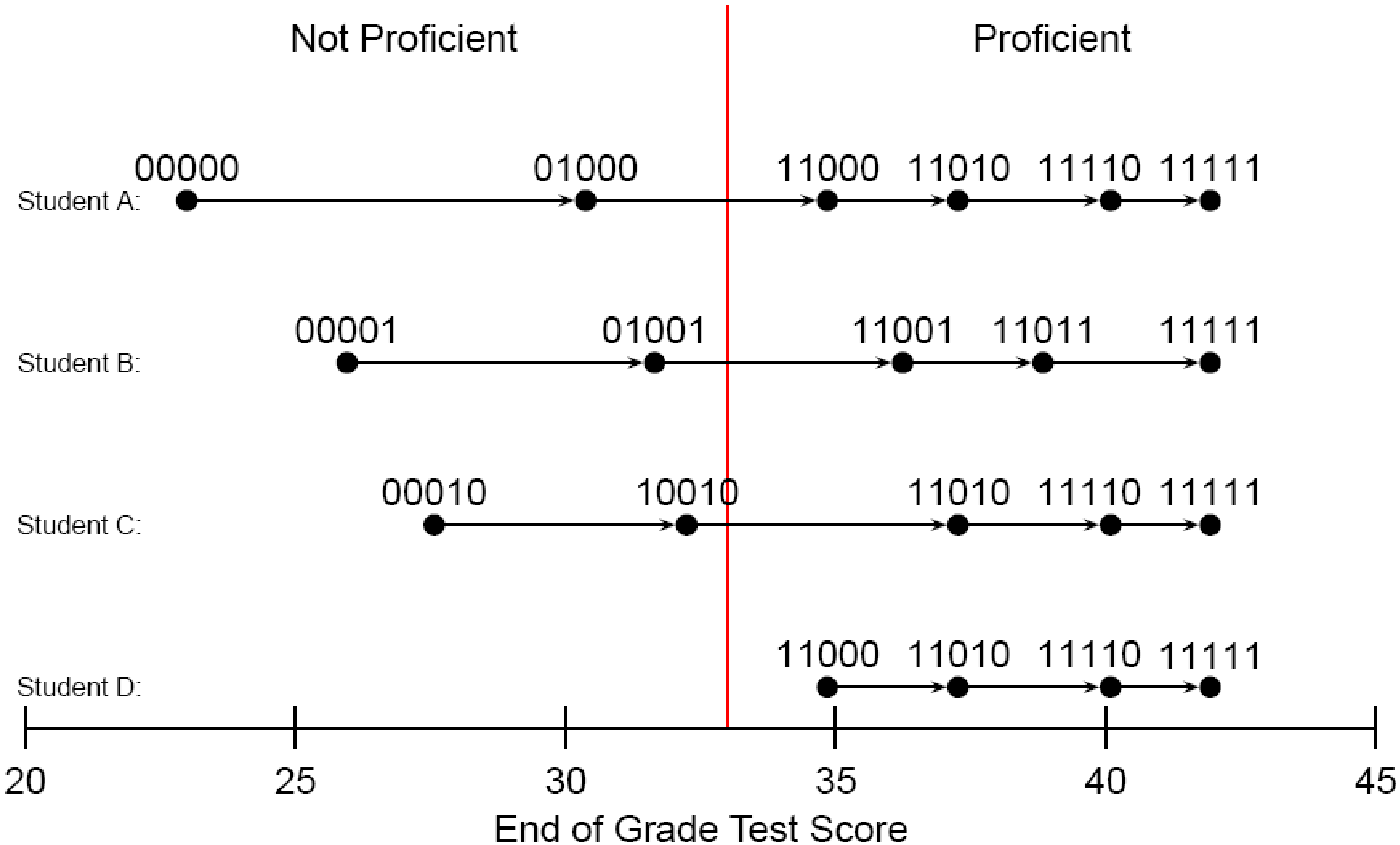
- This mechanism may help teachers decide focus on when teaching a course
  - Balances time spent on instruction with impact on test score

- Provides a practical implementation of DCMs in today's classroom testing environment

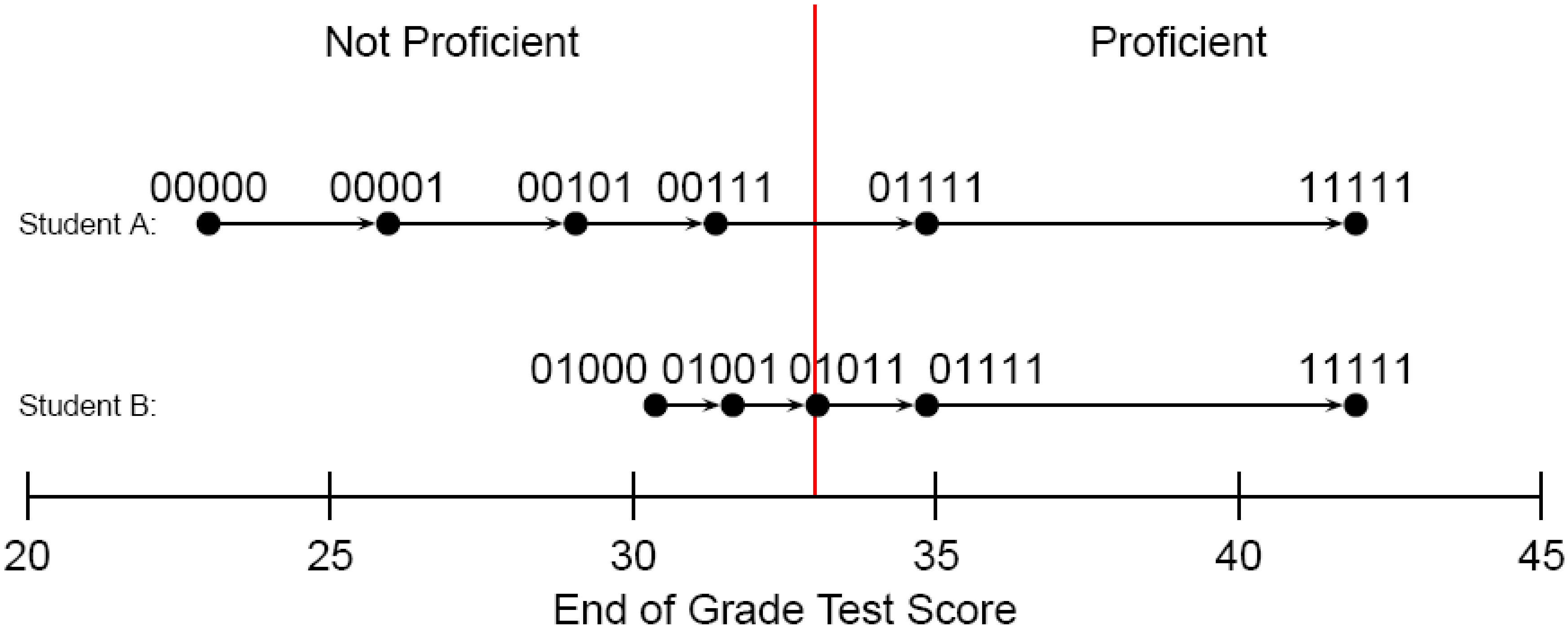
Proficiency Road Map



Fast Path to Proficiency



Harder Paths to Proficiency



- Some paths are less efficient at maximizing EOC test scores.
- This information comes directly from the joint analysis linking the benchmark test with the EOC test.

CONCLUDING REMARKS

Concluding Remarks

- DCMs provide a wealth of information that can be useful in helping students achieve and become proficient

- Such methods can help turn benchmark tests into opportunities to better understand the areas where students need the most help

- Tailored learning paths can be created, streamlining instruction of students by informing teachers of the skills students need to know

Concluding Remarks

- The impact of skill acquisition can be measured and observed, and can help schools meet AYP demands
- May help teachers understand how teaching curriculum may lead to direct increases in EOC test scores
- Could also be linked to other instruments(i.e., NAEP, SAT, or ACT)