Understanding the Impact of Skill Acquisition: Relating Diagnostic Assessments to Measurable Outcomes

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Outline

- Discussion of how Cognitive Diagnosis Models (CDMs) can aid in determining the best path to follow when teaching students.

- Relating CDMs to other important information.

  - Example end-of-grade test.

- CDMs used as formative tests:

  - How CDMs can be related to other tests.

  - Types of outcomes that can be expected.

  - Using information from CDMs to improve student performance.

Attributes Measured by Test

- Given the setting for our example, the benchmark test created was built to measure five basic skills in mathematics:

  1. Operate with algebraic expressions (polynomial, rational, complex fractions) to solve problems.

  2. Use the composition and inverse of functions to model and solve problems.

  3. Use quadratic functions and inequalities to model and solve problems.

  4. Create and use best-fit mathematical models of linear, exponential, and quadratic functions to solve problems involving sets of data.

  5. Use equations and inequalities with absolute value to model and solve problems.

Hypothetical Testing Cycle

Winter
- Administer Formative Test

Spring
- Remediate Students

EOG Testing
- Students Show Benefit of Taylored Teaching

Fall
- Initial Screening and Group Definition
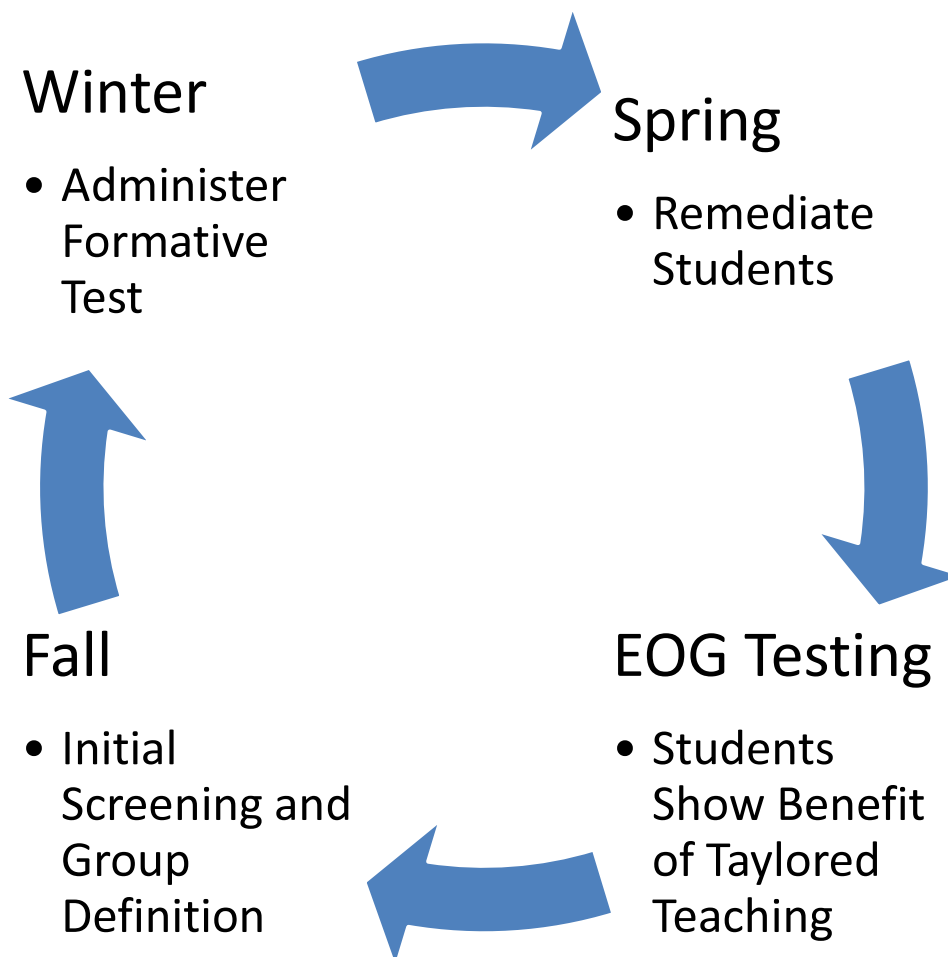
Potential Benefits to CDMs

- By constructing the benchmark test to measure attributes with CDMs, many benefits can be realized:

  - Student information comes from a profile of skills mastered.

  - The skills needed to perform well on the EOC test can be measured directly.

  - When developed as part of a curriculum, the benchmark test can lead directly to the EOC test.

  - Such development can allow educators to understand how much gain in an EOC test score is associated with students mastery of any given skill underlying the content of the test.

- This talk presents an example of what could be provided by linking a benchmark test with that of an EOC test.

Linking CDMs to Outcome Measures

- To link the diagnostic benchmark test and the EOC test, a joint calibration of both tests is needed.

1. Administer the EOC items should be simultaneously with the benchmark items.

    ❖ Examinees should take both tests at the same time.

    ❖ This will enable us to understand how certain skills relate to the scores on the EOC test.

    ❖ The EOC test does not have to be new.

    ❖ Does not have to be item level (can just be test score).

2. Determine the skill patterns of all examinees.

3. Relate the skill patterns to the EOC test score.

Demonstrating the Potential of CDMs

● To demonstrate the potential of CDMs analysis estimates to inform teachers, we include an hypothetical example.

● We take the 25 item benchmark test (described in the previous slides) as the test where examinee's knowledge states are assessed.

  ✦ Same five skills measured by the test.

  ✦ Skill acquisition could be considered meeting mastery standards.

● We link the attributes of the test to the general ability measured by the EOC exam.

Example Assumptions

- We made several assumptions in constructing this example.

- Biggest is about skill and ability association:

Skill	Proportion of Masters	Correlation with EOC Ability
1	0.70	0.81
2	0.60	0.81
3	0.50	0.63
4	0.40	0.63
5	0.30	0.45

- The higher the correlation between a skill and ability, the greater the impact the skill has on the EOC test score.

End of Course Test Development

- We constructed a hypothetical 50 item EOC test designed to mimic a minimum competency exam.

- Test created using a two-parameter item response model.

- Item difficulties ranged between -1.5 and -0.5.

- Item discriminations ranged between 0.5 and 1.5.

- We then superimposed a cutscore for proficiency of 32.

  ❖ This is where 60% of the population is considered proficient.

- The following results come from the joint calibration process.

  ❖ Here approximated using a simulation.

End of Course Test: Score Distribution

End of Grade Test Score Distribution
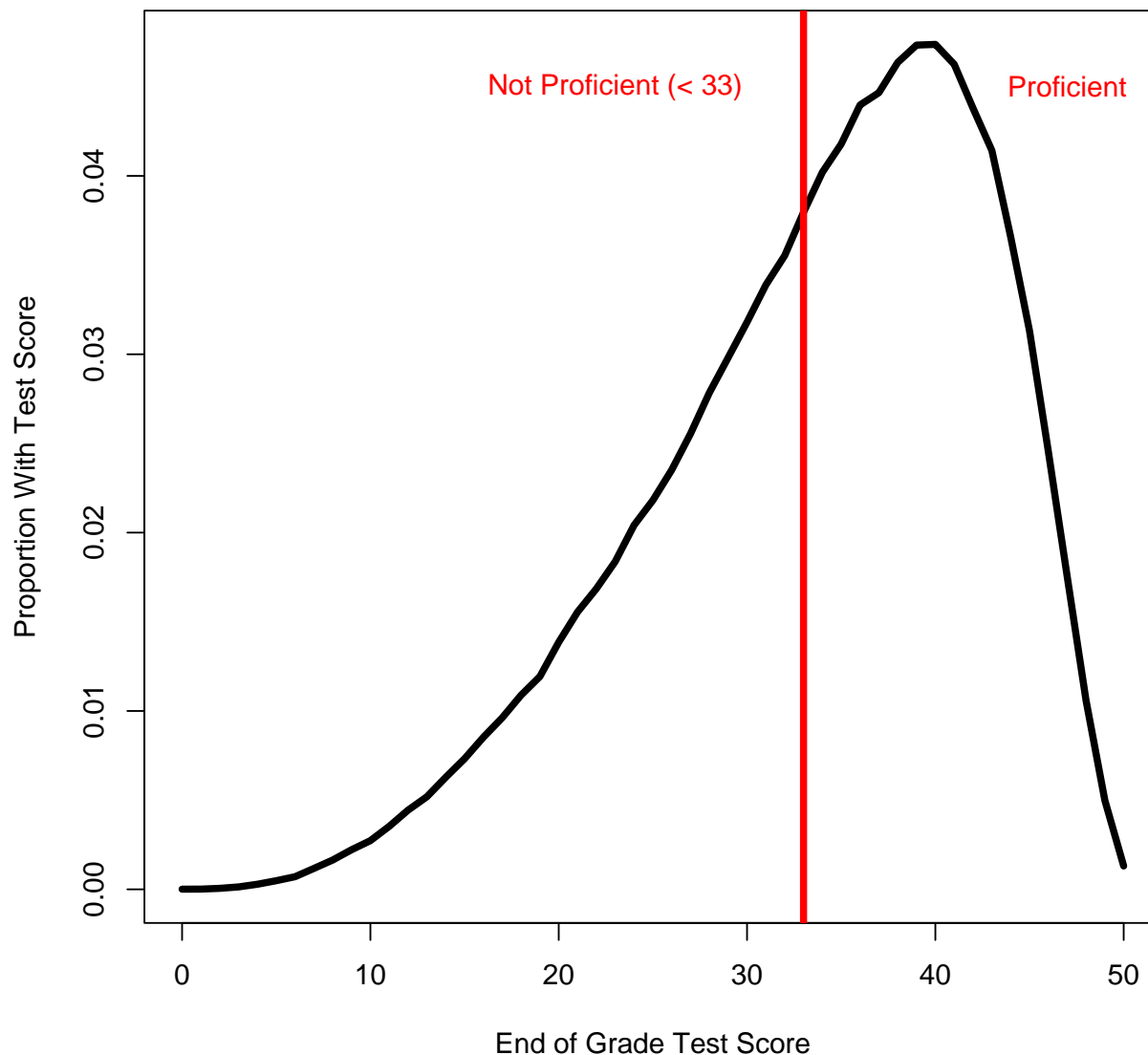
Descriptive Statistics of Skill Patterns

● To introduce the following slides, the first bit of information we present are the basic descriptives - how we would expect an examinee with a given skill 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 skill 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

● The higher the correlation between skill and ability, the higher the gain in test score.

● No correlation would lead to no expected increase in EOC score by mastery of a skill.

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.

- Specifically, each student is assessed to have mastered a set of the skills on the benchmark test.

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

- This mechanism may help teachers decide which skills to focus on when teaching a course.

  ❖ Balances time spent on instruction with impact on test score.

  ❖ Provides a practical implementation of CDMs in today's classroom testing environment.

Proficiency Road Map
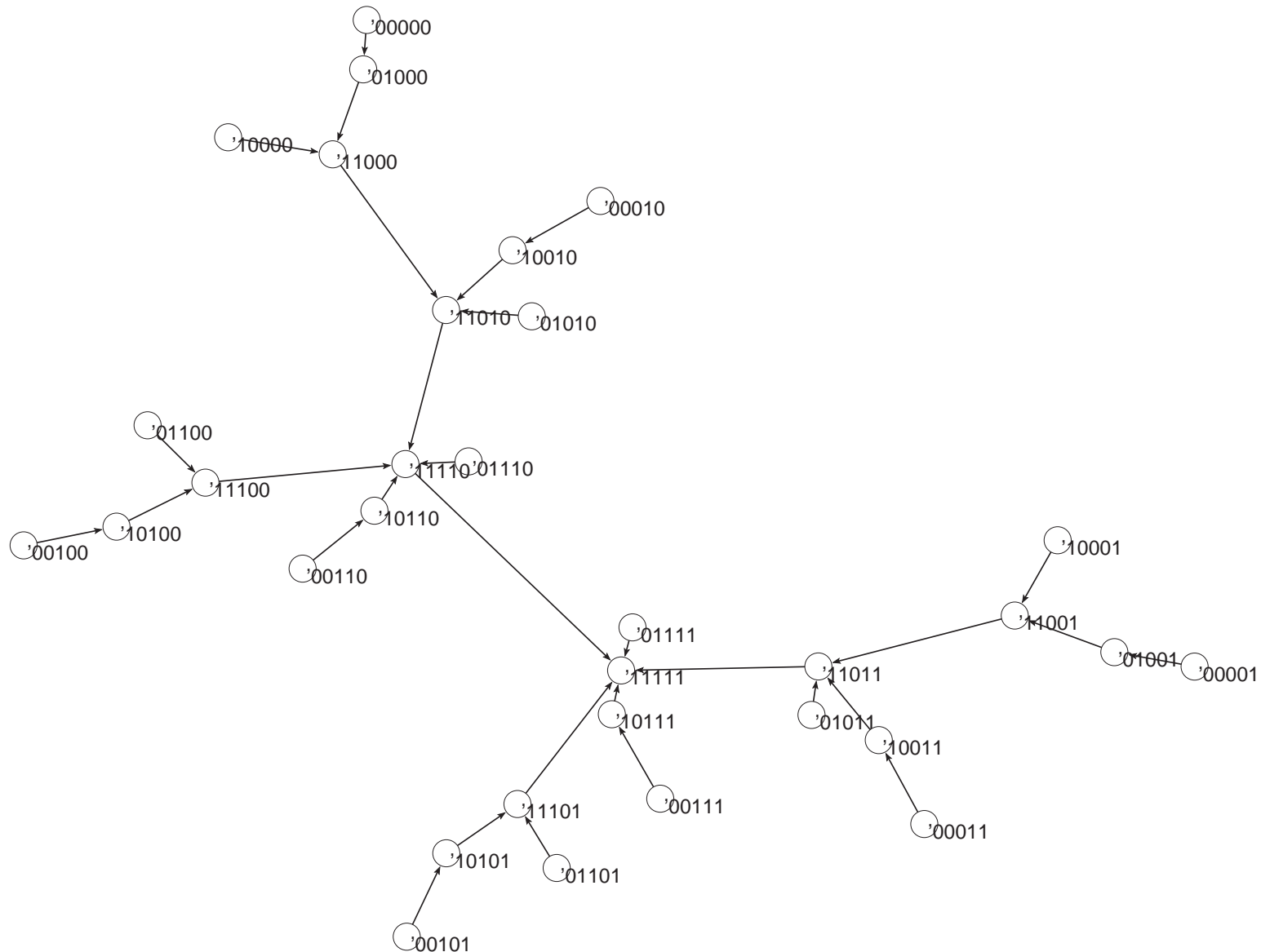
Fast Path to Proficiency

Not Proficient   Proficient

00000   01000   11000 11010 11110 11111
Student A:

00001   01001   11001 11011   11111
Student B:

00010   10010   11010 11110 11111
Student C:

11000 11010 11110 11111
Student D:

20   25   30   35   40   45

End of Grade Test Score
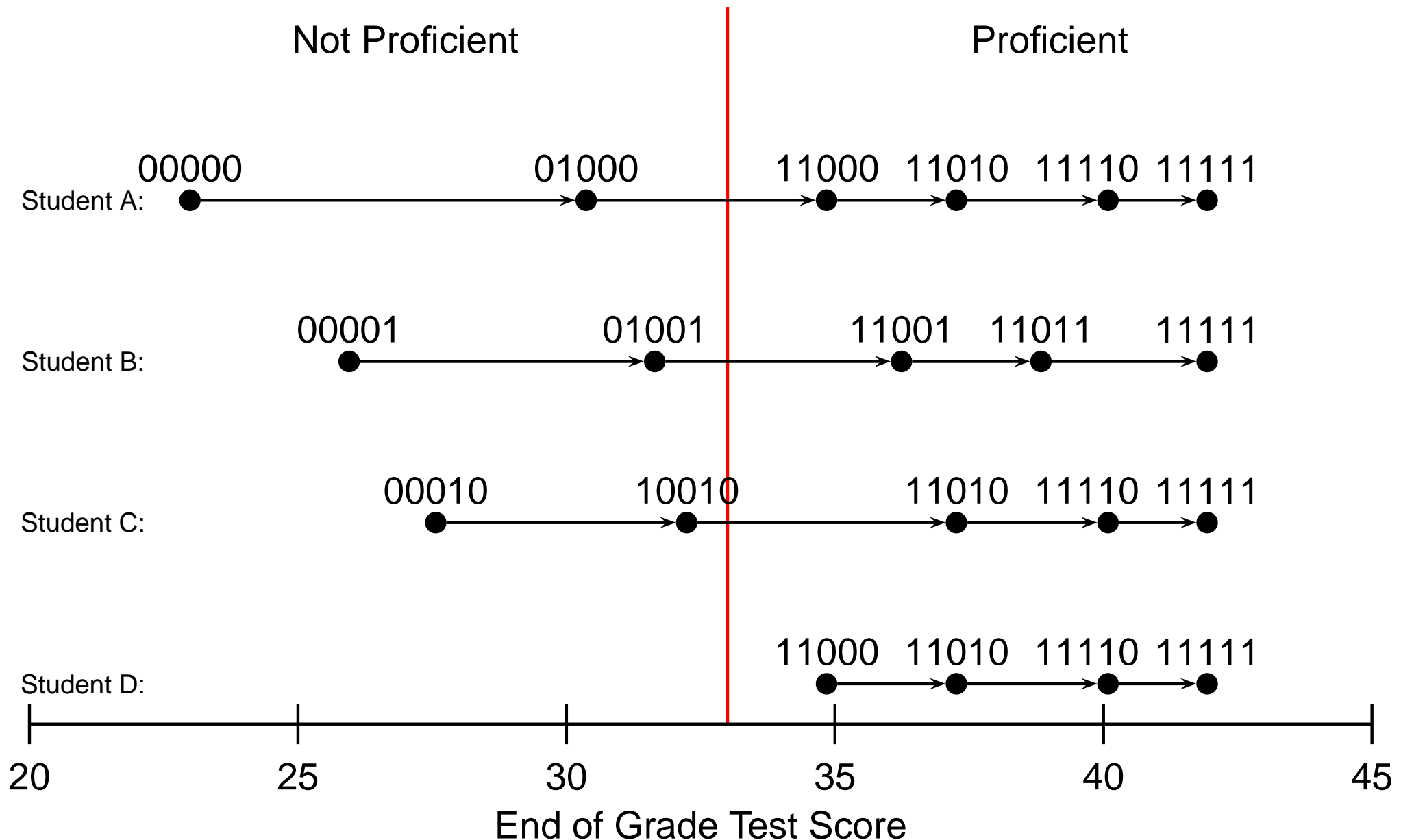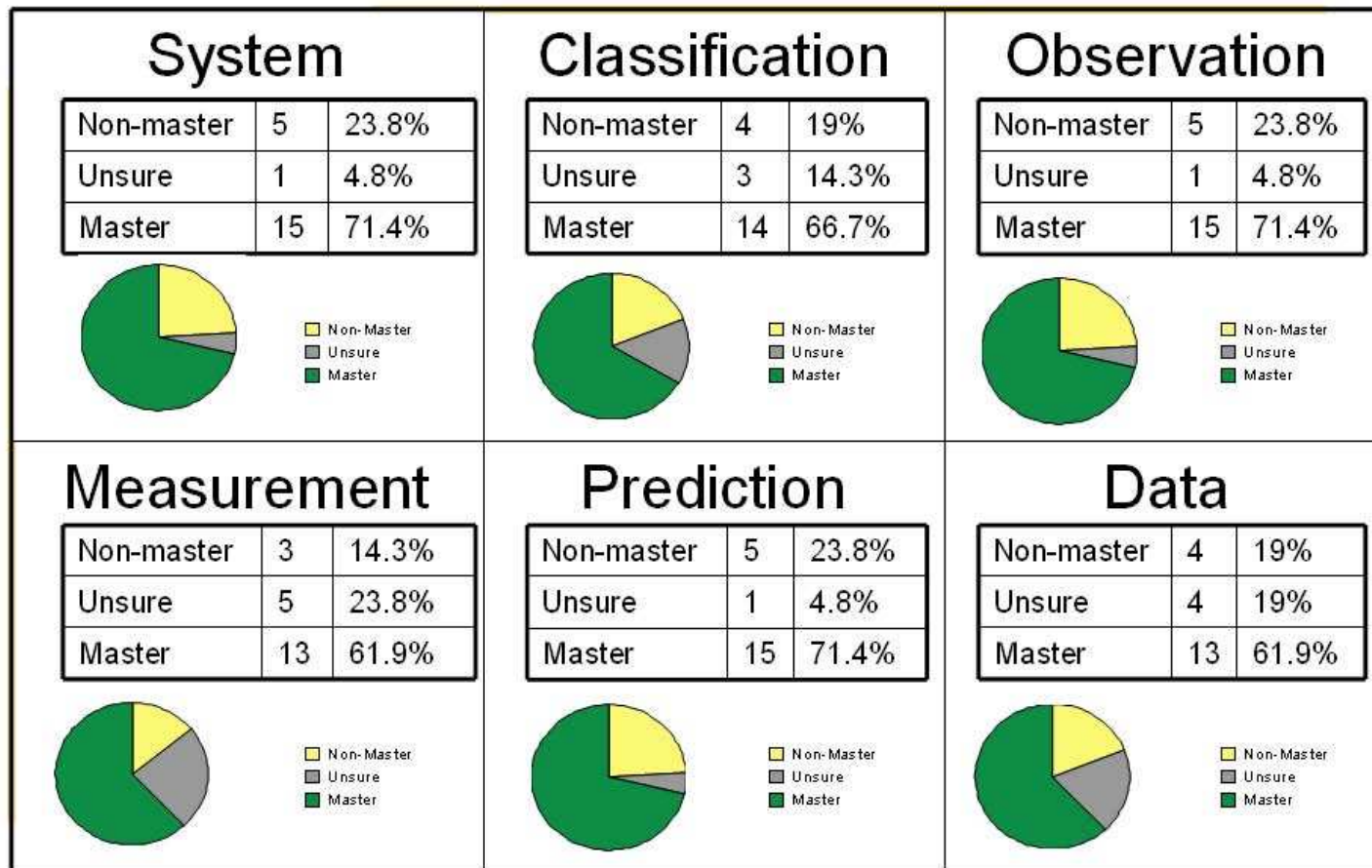
Harder Paths to Proficiency
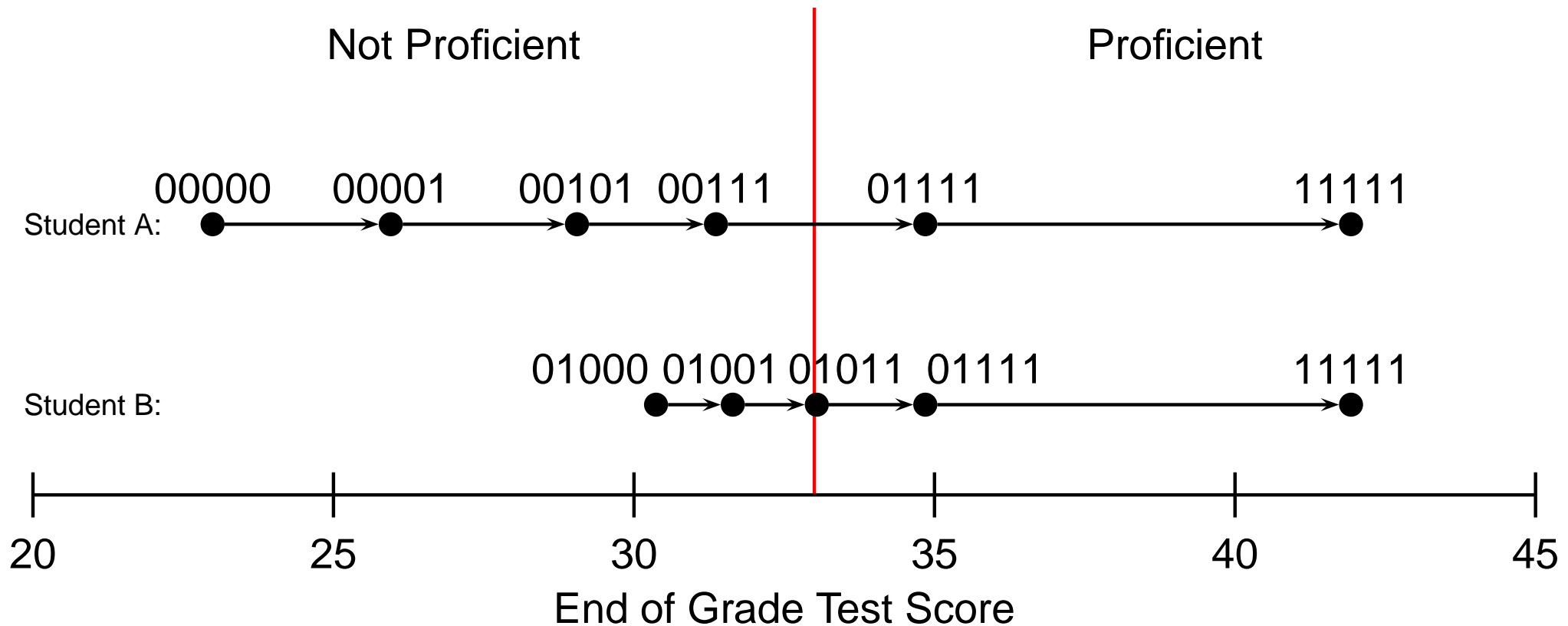
- Some learning paths are less efficient at maximizing EOC test scores.

- A teacher could balance the time it takes to teach a given skill with the expected gain in proficiency standing at the end of the course.

- This information comes directly from the joint analysis linking the benchmark test with the EOC test.

Example Classroom Report (Ackerman, NC-PIMS)

Mrs. Jones' 3rd grade class results

System

Non-master	5	23.8%
Unsure	1	4.8%
Master	15	71.4%

Classification

Non-master	4	19%
Unsure	3	14.3%
Master	14	66.7%

Observation

Non-master	5	23.8%
Unsure	1	4.8%
Master	15	71.4%

Measurement

Non-master	3	14.3%
Unsure	5	23.8%
Master	13	61.9%

Prediction

Non-master	5	23.8%
Unsure	1	4.8%
Master	15	71.4%

Data

Non-master	4	19%
Unsure	4	19%
Master	13	61.9%

Concluding Remarks

- CDMs 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.

- The impact of skill acquisition can be measured and observed, and can help schools meet AYP demands.

- May help teachers understand how teaching to curriculum may lead to direct increases in EOC test scores.

- Could also be linked to other instruments (i.e., NAEP, SAT, or ACT).

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