

How Do Students' Cognitive Profiles and Attribute Structure Vary Across Mathematical Domains?

A Cognitive Diagnostic Modeling Analysis

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INTRODUCTION & AIM

Mathematics assessment in schools often relies on total scores, which can hide students' specific strength and weaknesses at the attribute level.

This study aims to:

- Evaluate students' cognitive attribute mastery across several mathematics domains using Cognitive Diagnostic Modeling (CDM)
- Identify patterns of skill mastery with domain.
- Determine the most appropriate diagnostic model for assessment in each domain

METHODS

Design: Quantitative cross-sectional
Participants: 219 eighth-grade students from an Indonesian public junior high school
Instrument: 45 items from the final semester assessment
Domains: Basic statistics; Sequences and Series; Relations and Functions; Equations of Lines and Slopes; System of Linear Equation and Inequalities
Q-matrix: Developed through expert judgement to map items to cognitive attributes

ANALYSIS STEPS



Reliability: Cronbach's alpha = 0,84 (after dropping items 6, 26, 32, and 33)

DOMAIN ATTRIBUTES

Basic Statistics

BS1: Basic Statistical Concepts
BS2: Measures of Central Tendency

BS3: Measures of Data Dispersion

Sequence & Series

SS1: Basic Concepts
SS2: Arithmetic Sequences

SS3: Geometric Sequences
SS4: Application in Daily Life

Relations & Functions

RF1: Basic Concepts
RF2: Calculating and Visualising Relations

RF3: Calculating functions
RF4: Application in Daily Life

Equations of Lines and Slope

ELS1: Basic Concepts
ELS2: Calculating Slope

ELS3: Calculating Line Equations

System of Linear Equations and Inequalities

SLE1: Creating Mathematical Models
SLE2: Solving Linear Equations and Inequalities

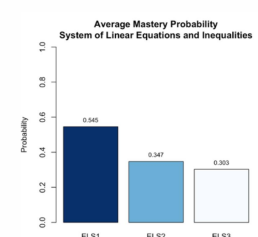
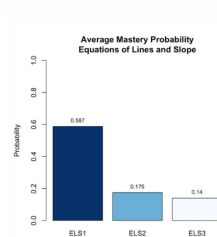
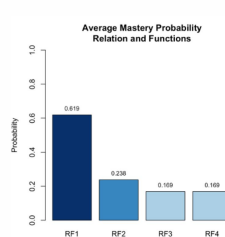
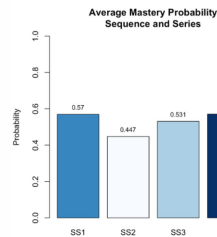
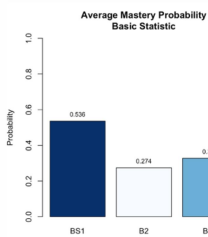
SLE3: Applying in Daily Life

KEY RESULTS SELECTED MODELS BY DOMAIN

Selected Models By Domain

Domain	Model	Interpretation
Basic Statistics	GDINA	Flexible/partially compensatory
Sequence & Series	GDINA	Flexible/partially compensatory
Relations & Functions	DINA	Hierarchical/ non-compensatory
Equations of Lines and Slope	DINA	Hierarchical/ non-compensatory
System of Linear Equations and Inequalities	DINA	Hierarchical/ non-compensatory

KEY RESULT AVERAGE MASTERY PROBABILITY OF ATTRIBUTES



DISCUSSION

- Basic Statistics and Sequences and Series** show more flexible and partially compensatory mastery patterns.
- In **Basic Statistics**, conceptual understanding appears to act as a prerequisite for central tendency and dispersion.
- Relations and Functions, Equations of Lines and Slopes, and Systems of Linear Equations and Inequalities** show stronger hierarchical patterns.
- Algebraic** domains reveal a cognitive bottleneck from conceptual understanding to procedural and applied competence.

CONCLUSION

- Students' cognitive profiles **vary substantially** across mathematical domains.
- CDM specification should be **domain-sensitive** and **aligned** with the epistemological characteristics of the content.
- Total scores alone are insufficient** because they do not capture attribute-level learning difficulties.
- Schools should incorporate **attribute-based diagnostic assessment** in summative mathematics testing.
- Instruction should strengthen the transition from conceptual to procedural competence**, especially in algebraic domains.

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