Paper Summary

<!--META_START-->

Title: Latent classes from complex assessments: What do they tell us?

Authors: Jake McMullen, Ryan W. Lewis, Drew H. Bailey

DOI: https://doi.org/10.1016/j.lindif.2020.101944

Year: 2020

Publication Type: Journal

Discipline/Domain: Educational Psychology

Subdomain/Topic: Latent Class Analysis in Mathematics Achievement Assessment

Eligibility: Eligible

Overall Relevance Score: 70

Operationalization Score: 55

Contains Definition of Actionability: Implicit

Contains Systematic Features/Dimensions: Yes

Contains Explainability: Yes

Contains Interpretability: Yes

Contains Framework/Model: Partial (applied LCA process)

Operationalization Present: Yes

Primary Methodology: Quantitative

Study Context: Application of LCA to 5th-grade math benchmark assessments to explore predictive value

Geographic/Institutional Context: Mid-sized, socioeconomically and racially diverse U.S. school district (W

Target Users/Stakeholders: Educators, school districts, educational policymakers

Primary Contribution Type: Empirical study with methodological evaluation

CL: Yes

CR: Yes

FE: Partial

TI: No

EX: Yes

GA: Partial

Reason if Not Eligible: n/a

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Year: 2020

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Discipline/Domain: Educational Psychology

Subdomain/Topic: Latent Class Analysis in Mathematics Achievement Assessment

Contextual Background: The study tests whether LCA applied to district-wide math benchmark asses

Geographic/Institutional Context: Mid-sized, socioeconomically and racially diverse school district in th

Target Users/Stakeholders: Educators, curriculum planners, district administrators, policymakers.

Primary Methodology: Quantitative

Primary Contribution Type: Empirical study evaluating methodological and practical utility of LCA.

General Summary of the Paper

This study investigates the practical and predictive value of applying Latent Class Analysis (LCA) to large

Eligibility

Eligible for inclusion: **Yes**

How Actionability is Understood

Actionability is implicitly defined as the ability of latent classes to yield *meaningful and useful patterns of

> “...such latent classes actually reflects actionable information for educators” (p. 3)

> “…identifying students whose patterns of knowledge suggest they are at greater risk…than their curren

What Makes Something Actionable

- Produces knowledge patterns that explain performance differences *beyond* overall scores.
- Identifies groups where targeted instruction in specific skills would be more effective than alternatives.
- Reflects knowledge states with different causal effects on future learning.
- Is interpretable in relation to domain theory (e.g., fractions as a pivotal skill).

How Actionability is Achieved / Operationalized

- **Framework/Approach Name(s):** Latent Class Analysis (LCA)
- **Methods/Levers:** Application of LCA to pass/fail benchmark standards to group students by knowled
- **Operational Steps / Workflow:**
  1. Fit multiple-class LCA models to benchmark pass/fail data.
  2. Select model based on BIC and interpret profiles.
  3. Compare profiles with similar overall performance but different knowledge patterns.
  4. Assess predictive validity for end-of-year standardized tests, controlling for covariates.

- **Data & Measures:** Pass/fail by curriculum standard, prior year standardized test scores, demographi
- **Implementation Context:** District-level assessments; could be implemented by school systems with e
> “...gleaning such actionable patterns…would be highly beneficial for educators” (p. 3)
> “...estimate an approximate range of effects…by statistically controlling…” (p. 3)
Dimensions and Attributes of Actionability (Authors’ Perspective)
- **CL (Clarity):** Yes – Profiles must be interpretable and coherent.
- **CR (Contextual Relevance):** Yes – Linked to specific curriculum standards and grade-level benchma
- **FE (Feasibility):** Partial – Method is implementable with existing district data, but practical gains are s
- **TI (Timeliness):** No – Study uses assessments months before the end-of-year exam, but timeliness i
- **EX (Explainability):** Yes – Classes must be interpretable in terms of cognitive development and curri
- **GA (Goal Alignment):** Partial – Supports targeted instruction toward high-leverage skills like fractions
- **Other Dimensions Named by Authors:** None explicitly labeled beyond above.
Theoretical or Conceptual Foundations
- Integrated theory of numerical development (Siegler et al., 2011)
- Prior LCA applications in cognitive development tasks (e.g., Piagetian tasks, conceptual change studies
- Theories on fractions as critical to mathematical development (Siegler et al., 2012)
Indicators or Metrics for Actionability
- Differences in predictive power of latent classes after controlling for overall performance and covariates
- Magnitude of residual effects (SD units) indicating potential causal importance of specific skill deficits.
Barriers and Enablers to Actionability
- **Barriers:**
  - Broad, complex tests mask specific cognitive states.
  - Pass/fail aggregation loses fine-grained information.
  - Small added predictive value after controls.
- **Enablers:**
  - Coherent, interpretable class structures.
  - Potential for identifying skill-specific deficits relevant to intervention.
Relation to Existing Literature
Positions LCA as promising in theory-driven contexts with narrow, well-defined constructs but cautions ag
Summary
This study evaluates whether latent class analysis applied to broad, curriculum-based math benchmark a
Scores

- **Overall Relevance Score:** 70 – Provides implicit, substantive criteria for actionability and ties feature
- **Operationalization Score:** 55 – Presents a replicable method for deriving and testing actionability fro

Supporting Quotes from the Paper

- “...such latent classes actually reflects actionable information for educators” (p. 3)
- “…identifying students whose patterns of knowledge suggest they are at greater risk…than their current
- “…gleaning such actionable patterns…would be highly beneficial for educators” (p. 3)
- “...estimate an approximate range of effects…by statistically controlling…” (p. 3)

Actionability References to Other Papers

- Siegler, Thompson, & Schneider (2011) – Integrated theory of numerical development.
- Siegler et al. (2012) – Fractions as central to math learning.
- Embretson & Yang (2012) – Theoretically grouped test items.
- Jansen & van der Maas (1997, 2002) – LCA in Piagetian balance scale tasks.