Coordinated Progress in Conceptual Understanding and Representational Competence

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Introduction

Researchers from the Berkeley Evaluation and Assessment Research center, the Assessing Data Modelling team at Vanderbilt University, and teachers from Phoenix, AZ and Northwest Arkansas collaborated in the effort of creating assessment system that captures the progression of student learning in the area of data modelling.

Data modelling refers to the skills and practices of making decisions about what and how to measure, the ways that data should be structured and displayed, and the conduct of inference. It is essential for students to learn these skills in order to understand the world and the problems it presents (Lehrer & Schauble, 2004).
To assess student understanding, we created 7 constructs spanning data modelling.

The constructs were developed from theory and research conducted in classrooms then refined through the process of creating items, developing scoring guides, assessing student work, and analyzing results.
This presentation reports on results from a multidimensional analysis of two constructs: Data Display (DaD) and Conceptions of Statistics (CoS).

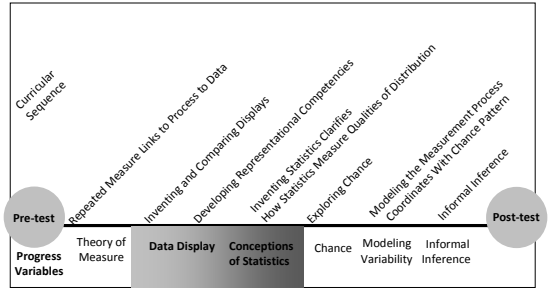
Participants

- 29 middle school teachers participated in teaching the introductory statistics curriculum. Teachers were supported by training materials and workshops.
- 658 students.
- Students in the same classrooms were all given the same pre-test form.

Instrument

- Subset of items from the pre-test instrument.
- 16 CoS related items.
- 9 DaD related items.
- Exemplars were developed for each item to match a range of students responses to locations on the construct maps .
- Exemplars were used for scoring.

Data Collection



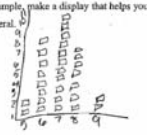
Example Items

- Homemade Bowling Part 1: (DaD) Item.

Danny created a homemade bowling game. In the game, he counted how many bottles, out of ten, he was able to knock down each time he rolled a ball. Here are the numbers of bottles Danny knocked down in 30 turns:

5, 6, 7, 7, 6, 8, 7, 6, 7, 8, 6, 7, 7, 9, 8
7, 6, 8, 7, 6, 6, 7, 9, 7, 8, 5, 8, 8, 6, 7

1. Given this sample, make a display that helps you think about how you expect Danny to perform in general.



- Exercise Ball Part 1: (CoS) Item.

A group of 7 students measured the circumference of an exercise ball. The measurements, in inches, are listed below. **Use these measurements to answer questions 1 and 2.**

Exercise Ball Measurements						
42	46	45	47	43	46	46

1. Find the median, mode, and mean of the ball's measurements and write your answers below. **Show your work in each box.**

Research Questions

- How does learning progress in Conceptions of Statistics and Data Display separately?
- How are Conceptions of Statistics and Data Display related?
- How is learning coordinated across the two constructs?

Theoretical Framework

- The one-dimensional constructs follow the learning progression in each area.
- Evidence of connections:
  - ✓overall theory
  - ✓item design

Level		Performances
Level 4	DaD4	Integrate case with aggregate perspectives.
Level 3	DaD3	Consider the data in aggregate when interpreting or creating displays
Level 2	DaD2	Recognize or apply scale properties to the data
Level 1	DaD1	Notice or construct groups of similar displays
Level 0	DaD0	Interpret and/or produce data displays as all collections individual cases
Pre-level 0	DaDpre	Create displays or interpret displays without reference to goals of data creation.

			Performances
Level 4	CoS4	D	Predict and justify changes in a sampling distribution based on changes in properties of a sample.
	CoS4	C	Predict that, while the value of a statistic varies from sample-to-sample, its behavior in repeated sampling will be regular and predictable.
	CoS4	B	Recognize that the sample-to-sample variation in a statistic is due to chance.
	CoS4	A	Predict that a statistic's value will change from sample to sample.
Level 3	CoS3	F	Choose/Evaluate statistic by considering qualities of one or more samples.
	CoS3	E	Predict the effect on a statistic of a change in the process generating the sample.
	CoS3	D	Predict how a statistic is affected by changes in its components or otherwise demonstrate knowledge of relations among components.
	CoS3	C	Generalize the use of a statistic beyond its original context of application or invention.
	CoS3	B	Invent a sharable (replicable) measurement process to quantify a quality of the sample.
	CoS3	A	Invent an idiosyncratic measurement process to quantify a quality of the sample based on tacit knowledge that others may not share.
Level 2	CoS2	B	Calculate statistics/indicating variability.
	CoS2	A	Calculate statistics indicating central tendency.
Level 1	CoS1	A	Use visual qualities of the data to summarize the distribution.

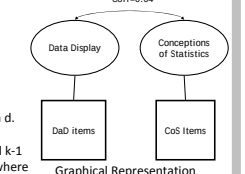
Multidimensional Random Coefficients Multinomial Logit (MRCML) Model

Log-odds of being at level k compared to level k-1 $= \vartheta_{pd} - \delta_{dik}$

Where :

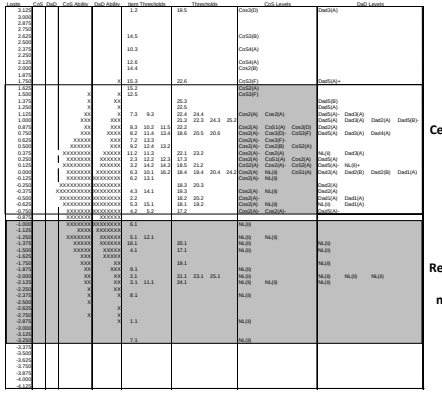
ϑ_{pd} is the ability of person p on dimension d.

δ_{dik} is the step difficulty of going from level k-1 to level k for the ith item for dimension d, where each item is an indicator for just one dimension.



Graphical Representation of the Two-Dimensional Model

Multidimensional Wright Map



Discussion of Findings

- Data Display and Conceptions of Statistics are reasonably correlated with each other, suggesting that they are related but separate constructs.
- At low ability levels, the domains converge. Relevant but flawed responses (NL(ii)) in both Data Modeling and Conceptions of Statistics were observed in the same region.
- Calculating statistics of central tendency (CoS 2(A)) is central to a major level of understanding associated with most levels of DaD.

Limitations and Future Research

- Because of the fact that many of the items in the analysis set were targeted at CoS 2(A), the conclusion about the connection between central tendency and CoS should be interpreted carefully.
- The post-test data will provide additional Information on changes within a certain student after taking the complete course. Analysis of the post-test data will include a latent growth item response model.

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