Improving Statistics Education:
Children Invent Representations, Measures and Models of Variability

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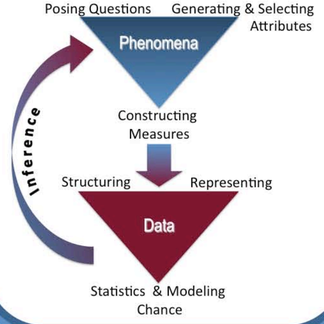
Introduction

The discipline of statistics originated in problems of modeling variability, yet these origins are often obscured by traditional statistics education.

Our approach is to engage children in data modeling, which coordinates inquiry with inference by involving students in the invention of representations, statistics, and chance-models of variability.



Design Studies

A hypothetical sequence of problems, tools, activities and forms of argument is designed to promote a conceptual ecology favorable to the development of disciplinary ideas and dispositions. The design seeks to leverage children's naïve knowledge to promote conceptual change.

The design is implemented in classrooms or other settings. Failure informs revision. Multiple iterations are conducted.

We designed instruction to begin with children's views of variability as mere difference and to culminate in reasoning about variability as a coordination between uncertainty and long-run pattern.

Design & Implementation in Fifth- and Sixth-Grade Urban Classrooms

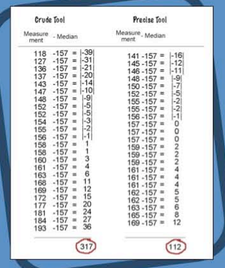
Repeated Measure Links Process to Data

Students all measure the same object, here the length of a teacher's arm-span and the height of a flagpole. Variability emerges from the collective action of individual measurers. Students use different tools (a meter stick, a 15 cm. ruler). These tools affect variability, an early link between process and what statisticians call distribution.

Inventing & Comparing Displays Develops Representational Competencies

Students consider how the shape of the data arises from the choices that designers make, especially choices about count, order, and interval.

Inventing Statistics Clarifies How Statistics Measure Qualities of Distribution



Students ask questions about the data. Their solutions to these questions reveal to account for differences in sample size.

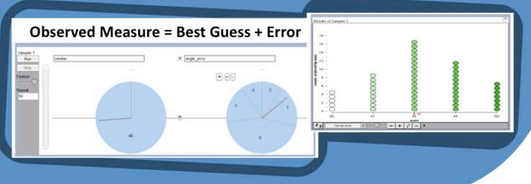
Questions include:

- What is the real length of the teacher's arm-span?
- How much did the measurers tend to agree?
- What was the effect of different tools

Modeling the Measurement Process Coordinates Chance with Pattern

Students model the distribution of measurements with Tinkerplots 2.0 (Konold).

- What kinds of errors did we make?
- Is this a good model for the real measurements?



Evidence for Conceptual Change

Flexible Interviews

Students in design classrooms and comparison classrooms are interviewed. The interview format allows for flexible follow-up to ascertain how students are reasoning. (See handout.)

The primary use of the evidence obtained is to improve design from iteration to iteration. A secondary use is to estimate improvement, if any, compared to other approaches.

Comparison data suggested that students participating in the design classrooms were more likely to:

1. Develop representational (**RC**) & meta-representational (**MRC**) competencies.
2. Understand chance (**C**) as coordinating uncertainty and structure.
3. Infer (**I**) population properties from sample properties.

	Concept	Design Classroom	Comparison Classroom
RC	Creating Displays for Real Data	87%	28%
RC	Translating between Displays	80%	61%
MRC	Choose Display to Make Quality Visible	30%	6%
C	Understand Chance as Coordinating Structure & Uncertainty	93%	39%
C	Coordinating Expectation & Variability in Repeated Sampling	73%	44%
C	Impossible vs. Improbable Events	93%	61%
I	Inference about Population from Sample	43%	31%

Based on the comparison data, instruction was re-designed to increase student skills in enumerating all outcomes in the sample space (**SS**) and in using chance when inventing measurement models (**M**):

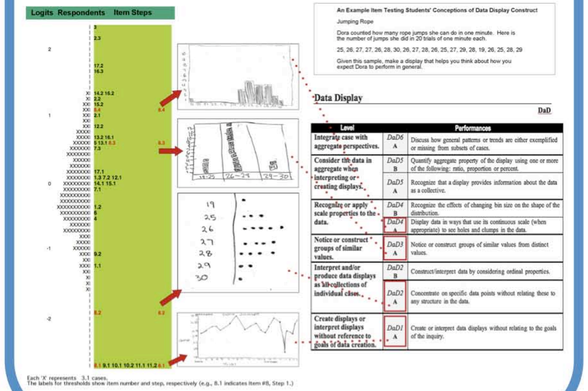
	Concept	Year 1	Year 2
SS	Generating Permutations	40%	69%
M	Constructing Spinners (Magnitude & Likelihood)	36%	54%
M	Using Spinners to Model Observed Measurements	42%	82%

Assessment System (Wilson)

Classroom studies suggest progress variables or constructs that span data modeling. Items are developed to span each construct. Student responses are fit to a latent trait model. Change is indicated by transitions in a multivariate profile. (See handout.)

The 7 Construct Maps Cover the following ideas:

- Theory of Measurement
- Data Display
- Meta Representational Competence
- Conceptions of Statistics
- Modeling Variability
- Chance
- Informal Inference



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