Assessment of Developing Scientific Practices

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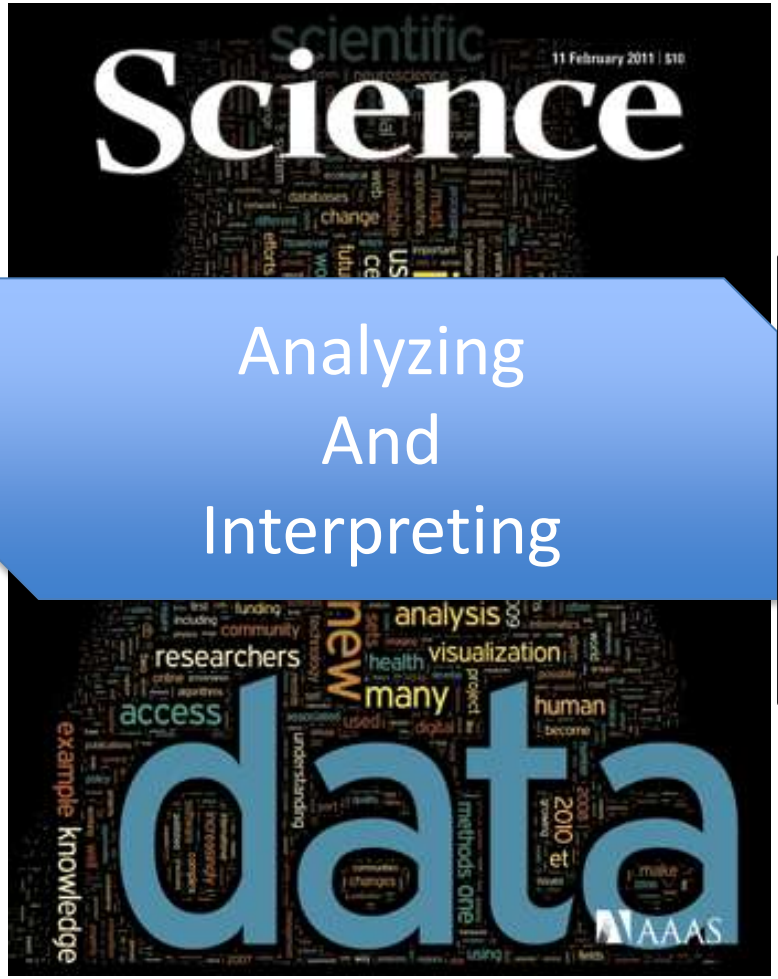
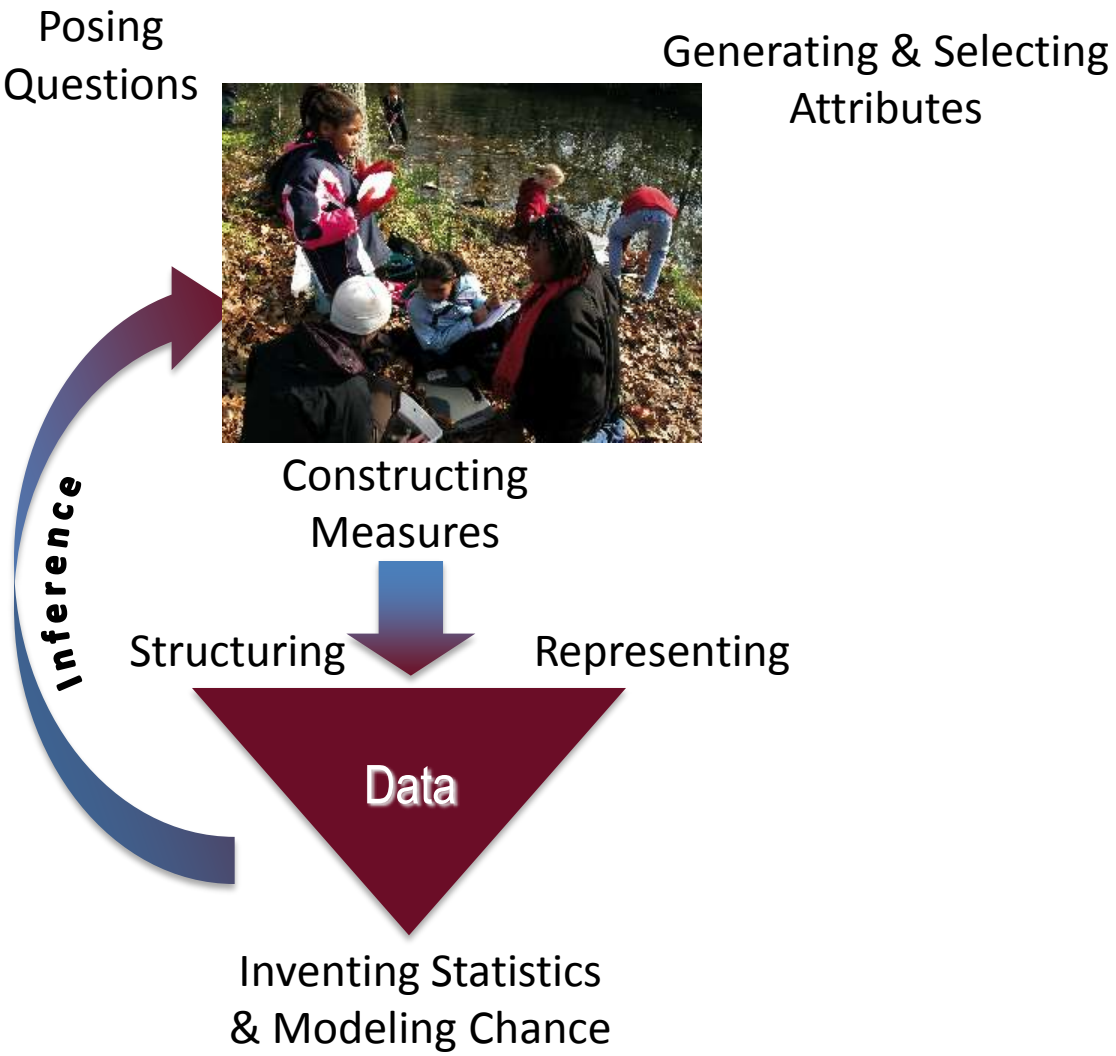
Phenomena



Modeling

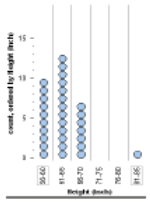
Constructing and Modeling Data



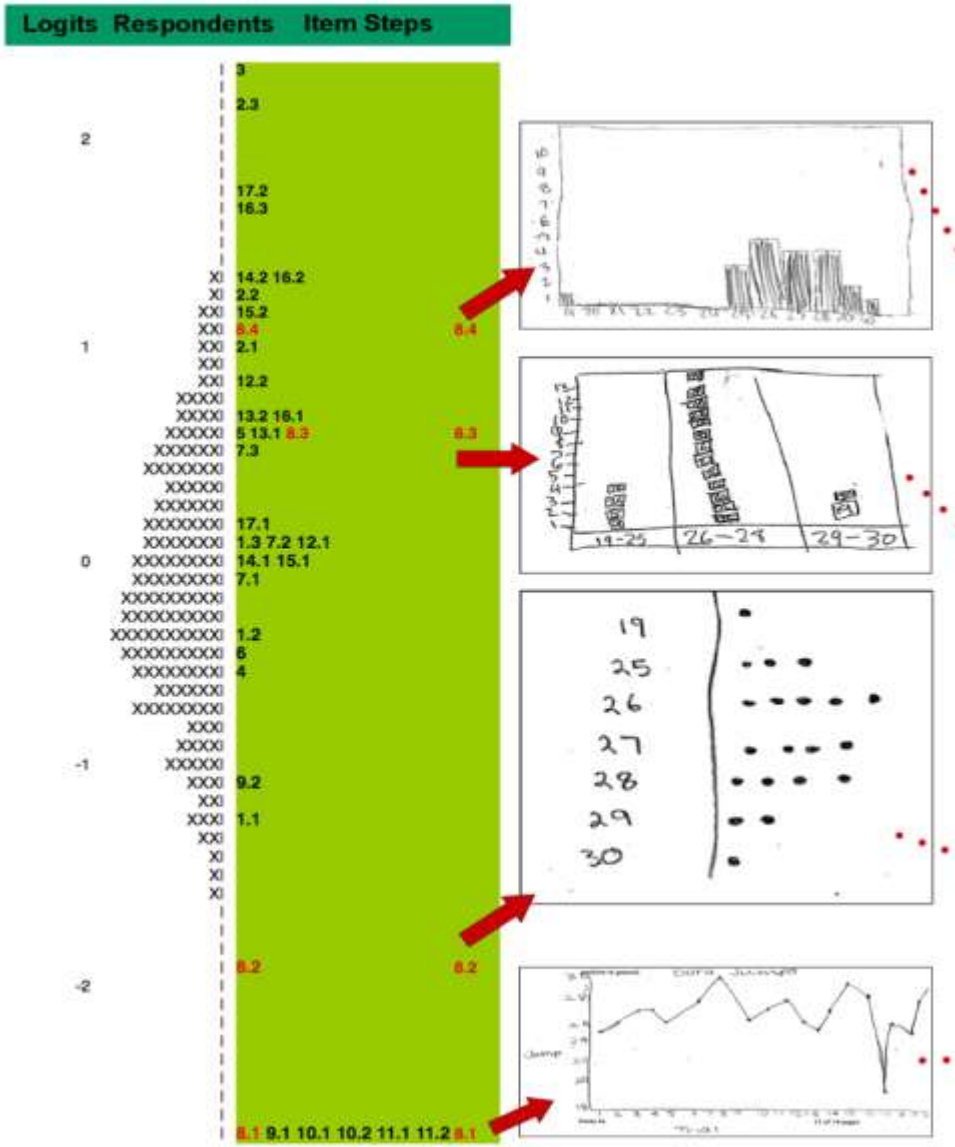
Construct	Initial Performance	Intermediate Performance	Highest Performance
Data Display (DaD)	DaD1(a): Create or interpret displays without relating to the goals of the inquiry.	DaD4(a): Display data in ways that use its continuous scale (when appropriate) to see holes and clumps in data.	DaD6(a): Discuss how general patterns or trends are either exemplified or missing from a subset of cases.
Meta Representational Competence (MRC)	MRC1(a): Recognize that displays represent data, but misinterpret one or more elements of the display.	MRC3(a): Compare displays by indicating what each shows about the structure of the data.	MRC5(b): Coordinate different display types and formats to strengthen an argument.
Conceptions of Statistics (CoS)	CoS1(a): Use visual qualities of the data to summarize the distribution.	CoS3(d): Predict how a statistic is affected by changes in its components or otherwise demonstrate knowledge of relations among components.	CoS4(d): Predict and justify changes in a sampling distribution based on changes in properties of a sample.
Chance (Cha)	Cha1(a): View chance as being under the control of an agent.	Cha4(c): Recognize that an "unlikely" string of outcomes is possible and even expected over many repetitions of the event. (e.g., 3H run in 10 coin tosses)	Cha6(b): Use sample space to estimate probability and/or relative frequency of a compound (aggregate event.
Modeling Variability (MoV)	MoV1(a): Attribute variability to specific sources or causes.	MoV3(a): Use chance devise to represent variability.	MoV5(a): Judge model fit in light of variability across repeated simulation with the same model.
Informal Inference (InI)	InI1(a): Make a judgment or prediction according to personal experience or beliefs.	InI4(a): Make predictions based on regions of values such as clumps or holes, sometimes identified by particular values.	InI 7(b): Compare two objects (conditions, etc.) by considering the variations in the sampling distributions of their statistics.

Data Display: Case ->Aggregate

DaD3	**Notice or construct groups of similar values.**	*DaD3* **A**	Notice or construct groups of similar values from distinct values.	▪ Create unordered bins, and comment on, for example, the number of occurrences of 40s vs. the number of 50s. ▪ When asked to name bins in a preset display, assigns discontinuous and/or unequal intervals to the bins, such as 2-25, 26-36, 37-45. ▪ Create equal interval bins but leave out intermediate intervals. ▪ Notice "plateaus" in the case display or a group of similar values. ▪ "This number, 193, is really different, because the others are all between 160 and 165." ▪ "Most of batteries lasted between 120 to 140 minutes."
DaD2	**Interpret and/or produce data displays as all collections of individual cases.**	*DaD2* **B**	Construct/interpret data by considering ordinal properties.	▪ "The data start out with the lowest measurement and go to the highest one." ▪ Create display by ordering data as a list or case-value graph.
		DaD2 **A**	Concentrate on specific data points without relating these to any structure in the data.	▪ Identify maximum and minimum values. ▪ "The only thing I can tell is this (193) is the highest." ▪ "154 is the number in the middle of the list (without ordering the data)." ▪ "This number is the biggest."
DaD1	**Create displays or interpret displays without reference to goals of data creation.**	*DaD1* **A**	Create or interpret data displays without relating to the goals of the inquiry.	▪ "We grouped even and odd numbers because we like even and odd numbers." ▪ "I put these two values (19 and 11) on the top because that's my birthday - Nov. 19th!" ▪ "This display has lots of numbers."

Level		Performances		Examples
DaD6	**Integrate case with aggregate perspectives.**	*DaD6* **A**	Discuss how general patterns or trends are either exemplified or missing from subsets of cases.	▪ Relate qualities of a case as an example of general qualities of a region of data (case as typical of data region). ▪ Notice that a subset of cases does not seem to fit the trends observed or conjectured.
DaD5	**Consider the data in aggregate when interpreting or creating displays.**	*DaD5* **B**	Quantify aggregate property of the display using one or more of the following: ratio, proportion or percent.	▪ "I found out that measurements between 45 and 55 were 70% of our measurements. So, I guess the true height is somewhere between 45 and 55." ▪ Students annotate their display to show percentages within particular regions.
		DaD5 **A**	Recognize that a display provides information about the data as a collective.	▪ "The distribution of the data is wider for rounded-nosecone rockets than for pointed-nosecone rockets. Maybe that's because pointed rockets flights are more consistent." ▪ "When we measure different things, we keep getting a bell shape. That's because we tend to get around the real measure most of the time, but sometimes we make big mistakes."
DaD4	**Recognize or apply scale properties to the data.**	*DaD4* **B**	Recognize the effects of changing bin size on the shape of the distribution.	▪ "If we make bin size wider, the tower in the center will pop up."
		DaD4 **A**	Display data in ways that use its continuous scale (when appropriate) to see holes and clumps in the data.	-"Number line" display:  - "Bin" display: 

Summative Item Design



An Example Item Testing Students' Conceptions of Data Display Construct

Jumping Rope

Dora counted how many rope jumps she can do in one minute. Here is the number of jumps she did in 20 trials of one minute each.

25, 26, 27, 27, 26, 28, 30, 26, 27, 28, 26, 25, 27, 29, 28, 19, 26, 25, 28, 29

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

Data Display

DaD

Level		Performances
Integrate case with aggregate perspectives.	*DaD6* A	Discuss how general patterns or trends are either exemplified or missing from subsets of cases.
Consider the data in aggregate when interpreting or creating displays.	*DaD5* B	Quantify aggregate property of the display using one or more of the following: ratio, proportion or percent.
	DaD5 A	Recognize that a display provides information about the data as a collective.
Recognize or apply scale properties to the data.	*DaD4* B	Recognize the effects of changing bin size on the shape of the distribution.
	DaD4 A	Display data in ways that use its continuous scale (when appropriate) to see holes and clumps in the data.
Notice or construct groups of similar values.	*DaD3* A	Notice or construct groups of similar values from distinct values.
Interpret and/or produce data displays as all collections of individual cases.	*DaD2* B	Construct/interpret data by considering ordinal properties.
	DaD2 A	Concentrate on specific data points without relating these to any structure in the data.
Create displays or interpret displays without reference to goals of data creation.	*DaD1* A	Create or interpret data displays without relating to the goals of the inquiry.

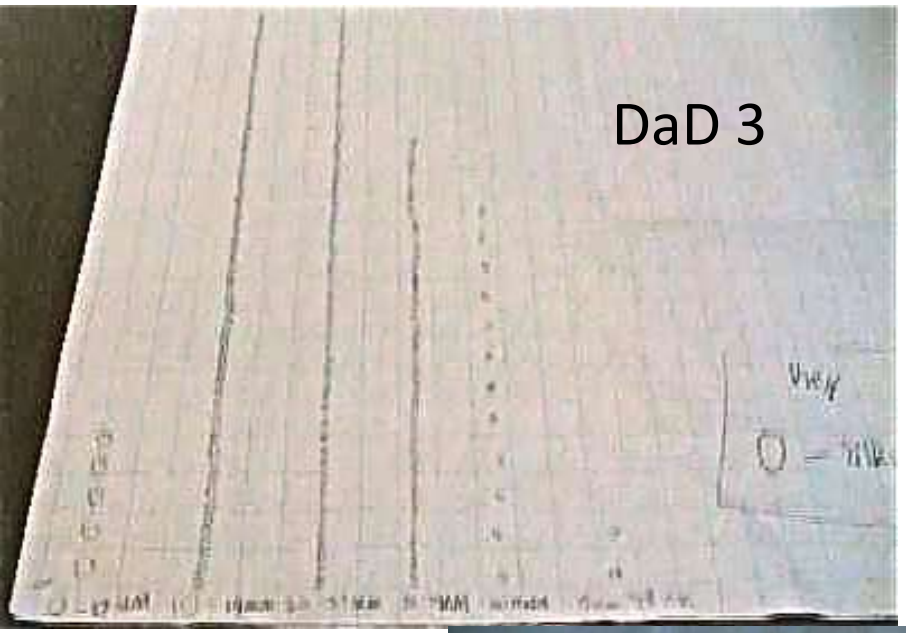
Data Display as a Scientific Practice

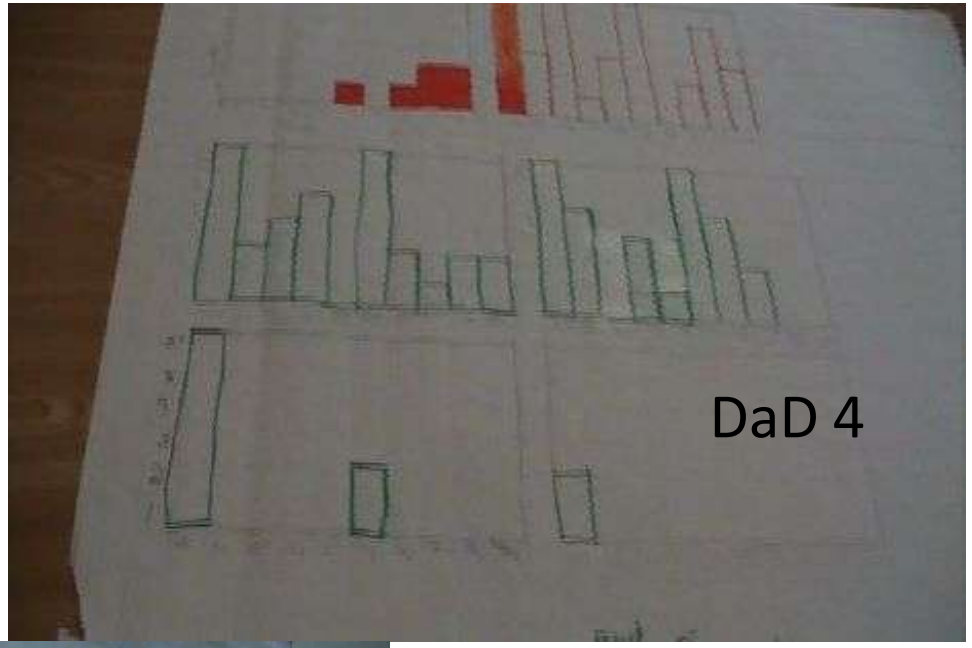
- Grade 3 Investigations of Organism Growth
- Context: Social Studies, Role of Silkworms
  - Students investigations of
    - Conditions for Hatching Eggs
    - Growth
      - Structure-function (mouthparts)
      - Indicators of growth (measure length)
      - Challenge: For a day of growth, create a display of the data that shows something that you noticed about the measurements—some pattern or trend—so that someone else looking at your display can see what you notice. (n = 241 larvae)
      - Display review. Class compares displays re show and hide.

Knowledge Practice

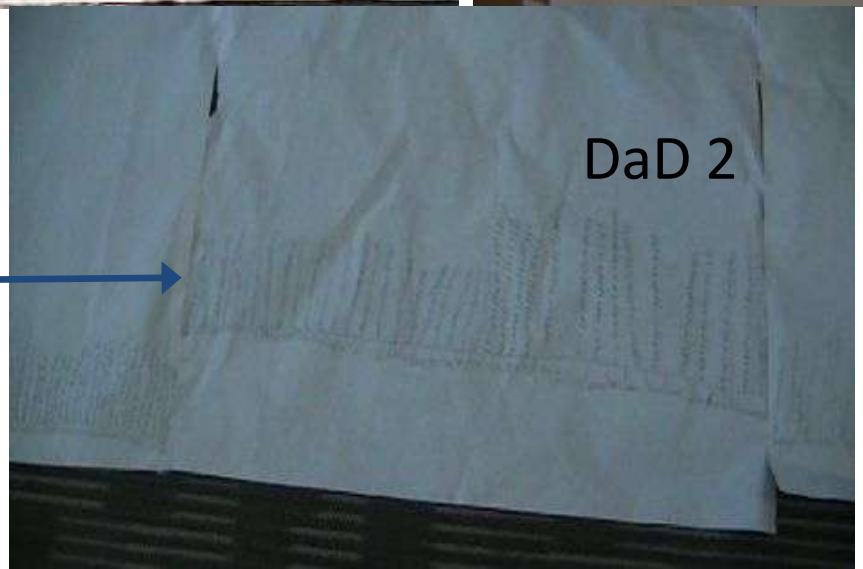
- Shape of Data as bridge between organism and population levels of thinking, a key to reasoning about evolution.
- Shape of data may provoke new forms of inquiry.

Invented Displays

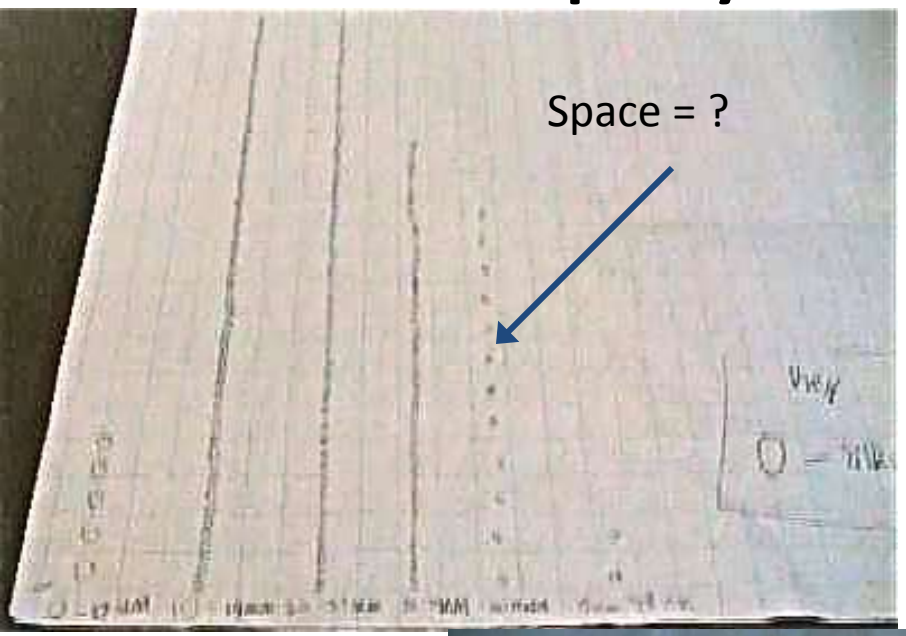


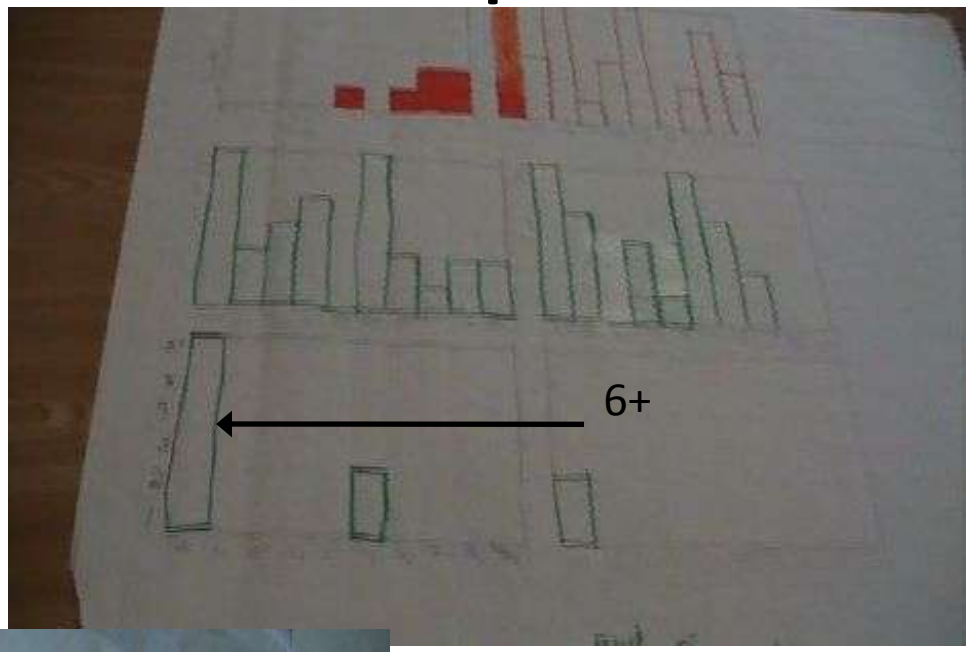


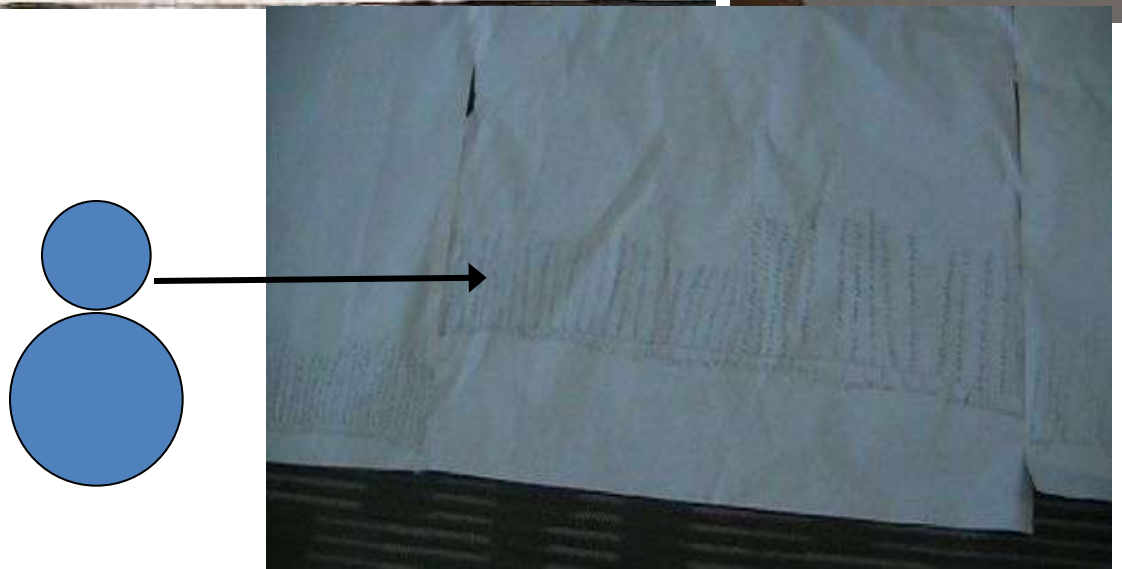
Case Value



Representational Competencies Display Review Critique





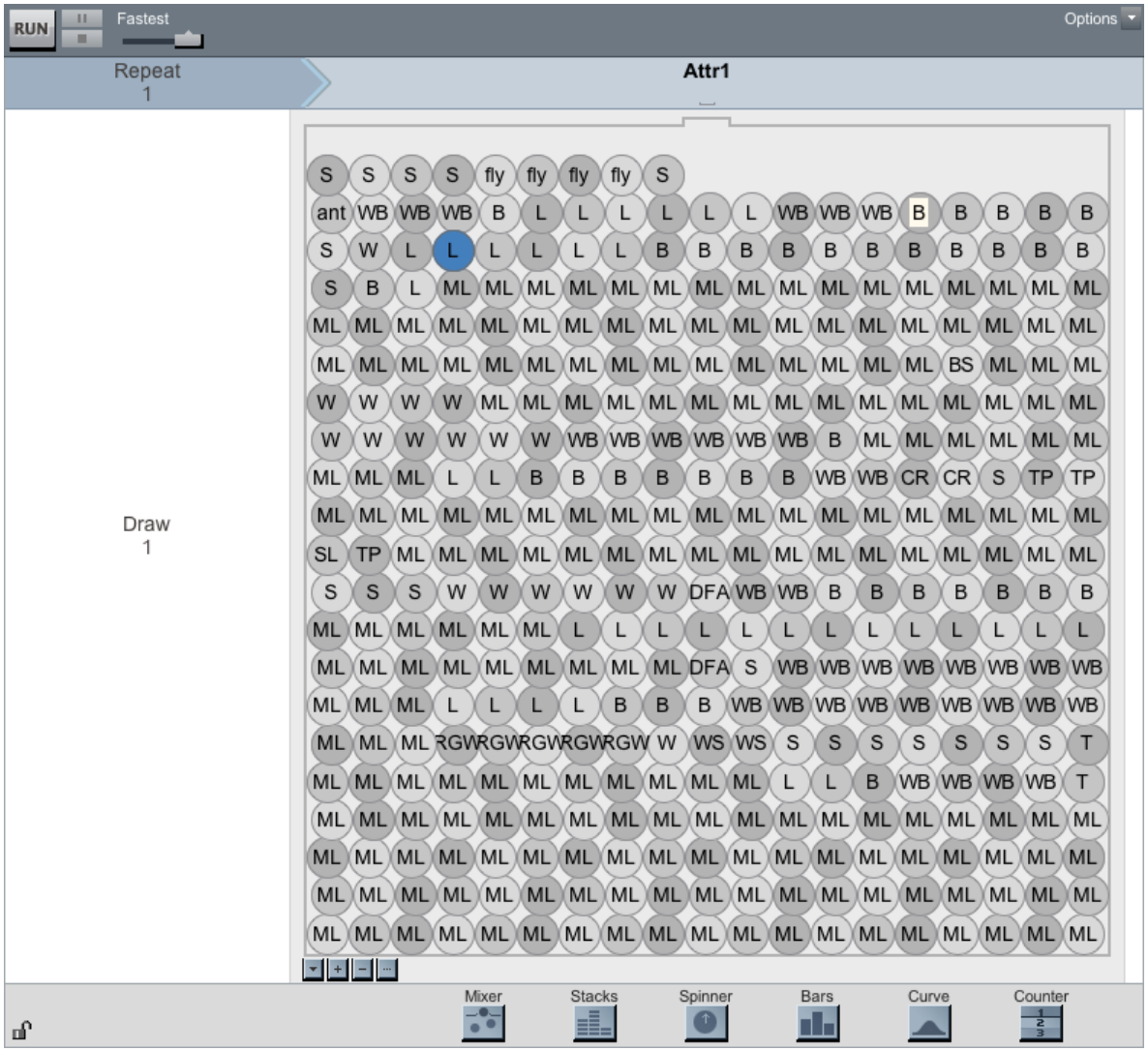


Display-based Reasoning
What about the tail?

Some Tentative Conclusions

- Constructs describe and make conjectures about the order of states of learning—what is worth assessing—an outcome space.
- Theories of learning guide conjectures about supporting transitions between states.
- Formative assessment is the union of ways to support transitions (invention, talk) guided by images of outcome progression.

Modeling Natural Systems (G6)



Conjectures about diversity and partitions of a pond.

Difference or chance?

Bootstrap samples.