

The Invention Support Environment

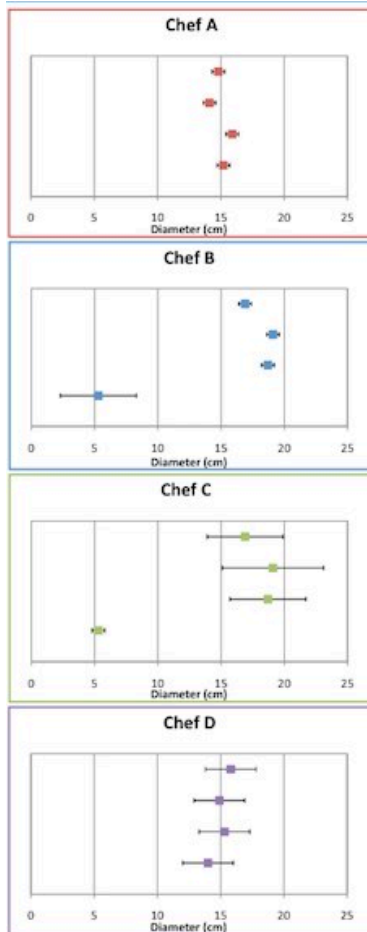
Where do we go from here?

Natasha Holmes, Ido Roll, James Day & Doug Bonn

Context

- Invention Activities
 - Activities where students are asked to invent a method to solve a problem before being taught the domain
 - Least-squares fitting
 - Weighted Average
 - Weighted Least-squares fitting
 - Slope Uncertainty with fixed intercept
 - T-test
- Invention Support Environment
 - Computer-based learning environment built to support invention activities (Holmes, N. 2011)

ISE: Weighted Average



Initial Final

2

3

2

1

Show Data
Edit Names

Intro

Section1

Section2

Invent a procedure to help each sous-chef calculate a single value to report as the diameter of their ostrich egg. Use the space to build a general formula for the index that can calculate a single value for each group. You may use the operators and symbols in the Equation Editor (below) as well as the keys on your computer keyboard.

Rules:

1. Each sous-chef can only report a single value as the diameter of the egg.
2. The exact same procedure must be used for each sous-chef's dataset.
3. The equation must reflect the criteria described for the rankings above.

Equation Editor toolbar:

$$\bar{x} = \frac{\sum \frac{x_i}{\delta_i}}{\sum \delta_i^2}$$

Please explain how your formula reflects the rankings made in Section 1.

divide each point by the uncertainty, then divide by the total weight to fix units.

Section3

Section4

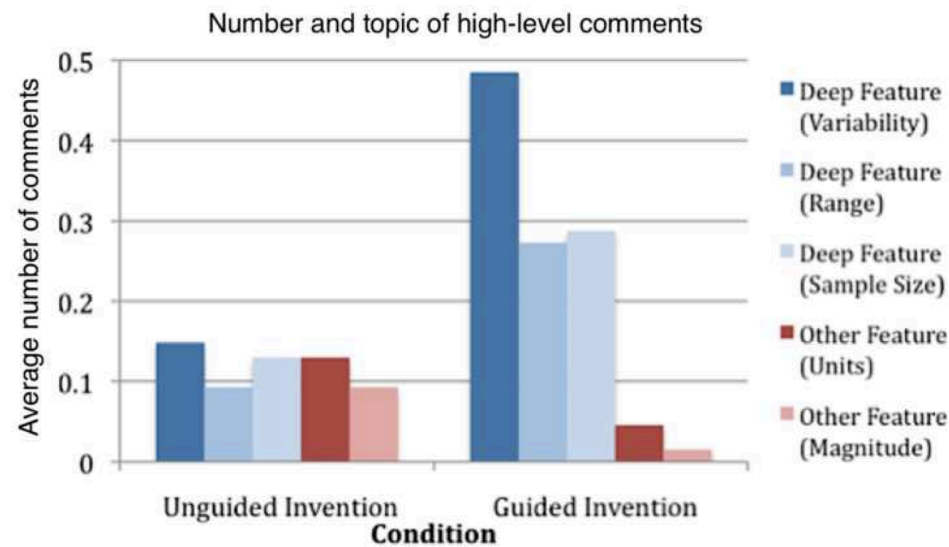
Experimental conditions

Scaffolding stages*	Treatment Group	Control Group
Exploratory analysis	<ul style="list-style-type: none"> ▪ Pairwise Comparisons ▪ Ranking ▪ Self-explanation 	
Planning and design	<ul style="list-style-type: none"> ▪ Build Equation ▪ Self-explanation 	<ul style="list-style-type: none"> ▪ Build equation
Implementation	<ul style="list-style-type: none"> ▪ Apply equation ▪ Ranking datasets 	<ul style="list-style-type: none"> ▪ Apply equation
Evaluation	<ul style="list-style-type: none"> ▪ Self-explanation 	

*Roll, Holmes, Day & Bonn (2012) Using metacognitive scaffolding to improve the inquiry process and its outcomes in guided invention activities

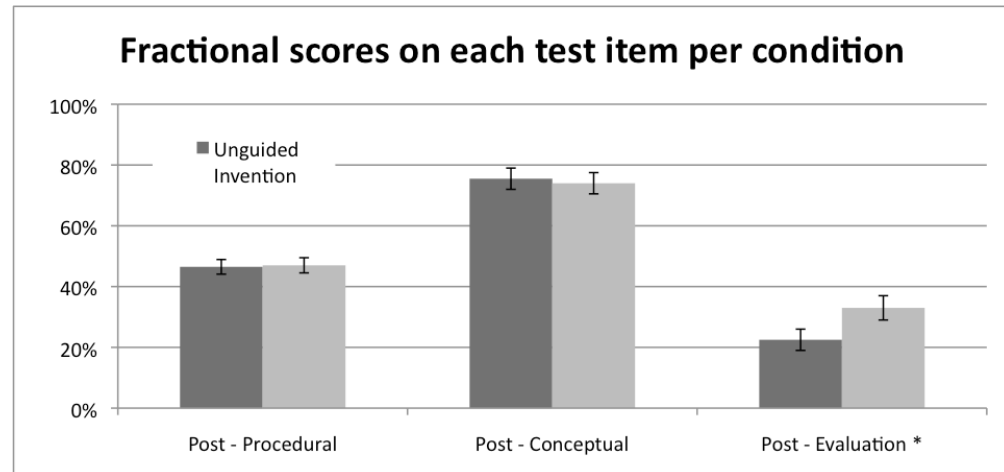
Quality of Inventions

- Individual invention activities (Roll, et al. 2012)
 - Quality of inventions
 - Quality and quantity of self-explanations
- Slope Uncertainty/Fuel Consumption
 - Analyzed this activity in 2010, 2011



Domain Learning

- Pre- and post-study statistics test
 - 5 domains
 - 3 question types:
 - Conceptual
 - Evaluation
 - Transfer



- Previous found that metacognitive scaffolding improves performance on evaluation questions but has no effect on conceptual or procedural questions.*

*Holmes, N. (2011) The Invention Support Environment: Using metacognitive scaffolding and interactive learning environments to improve learning from invention. MSc. Thesis, *University of British Columbia*

Instruction Tasks

- What matters

Identify features from multiple choice list

Now that you've completed the invention activity, what features of the data did you notice as being important? That is, what are the characteristics for a single value that compares various measurements? Select all that apply.

- Divide by number of data points
 - Give greater weight to points with smaller uncertainty
 - Give smaller weight to points with smaller uncertainty
 - Include all data points
 - Ignore outliers
 - Account for the total weighting
 - Keep all arguments in the sum positive
- [Check](#)

[Next Section](#)

No, this is not correct. You correctly selected Give greater weight to points with smaller uncertainty, but what are the other features?

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The previous invention activity asked you to invent a method for calculating a single value to report from various measurements with different uncertainties. The method typically used is the weighted average. The formula for weighted average tackles three concepts or features:

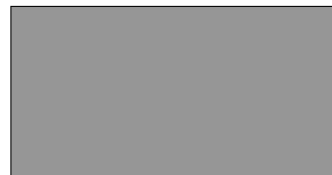
1. Include all data points in the calculation, with some form of weight (w_i). We weigh each value by some factor so that values with higher weights will factor more strongly into the average than values with lower weights.
2. Give greater weight to points with smaller uncertainty. This will have an effect that outliers with large uncertainties will be negligible in the calculation, but also takes care if an outlying value has a very small uncertainty.
3. Account for the total weighting by normalizing over all points. This is done by dividing by the sum of the weights and controls for the units, magnitude and number of data points.

$$\sum x_i \cdot w_i$$

$$w_i = \delta x_i^2$$

Connect each of the features for weighted averages, above, with the best mathematical representation that accomplishes the feature, from the area below, by dragging the equation parts to the grey boxes on the right. Use the fourth grey box at the bottom of the screen as a recycle bin to remove

$$\frac{\sum(\dots)}{\sum w_i} \quad \frac{1}{N} \sum(\dots) \quad w_i = \frac{1}{\delta x_i^2}$$



This method of weighting gives higher weight to larger uncertainties, rather than the other way around.

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[Done](#)

- Drag and drop
Connect features to mathematical representations

Practice Tasks

- Procedural
 - *Calculate the index for different data sets*
 - *Self-explanations*

Here is another example of where a weighted average can be used. Three different liquids are combined into a container in different volumes, as in the table provided. How can you determine the density of the final liquid?

Liquid	Volume (mL)	Density (g/mL)
A	100	1.02
B	10	0.72
C	500	1.033

What are the data points in this problem?

What are the weights in this problem?

How do you normalize to get the final density?

What is the average density of the final liquid (to 2 decimal places, in g/mL)?

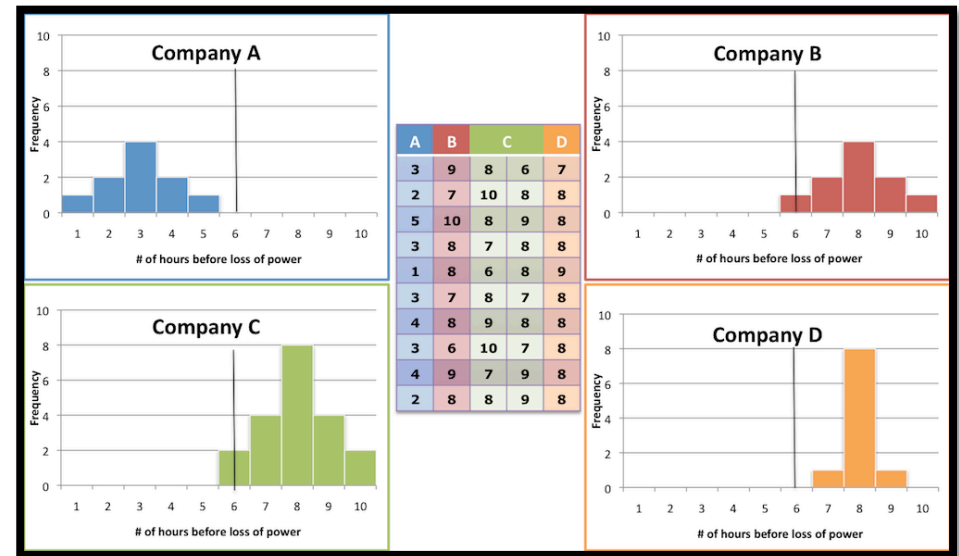
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Done

- Transfer
 - *Evaluate a variation on the formula*
 - *Apply to a new situation*

Transfer activities

- T-test invention activity
 - *Both in low scaffolding*
 - *Quality of inventions*
 - *Quality of self-explanations*

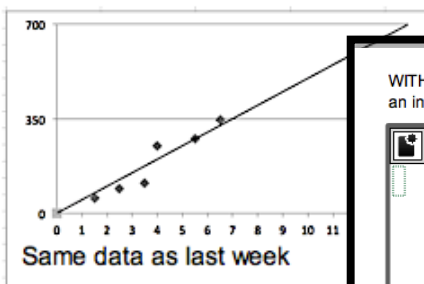
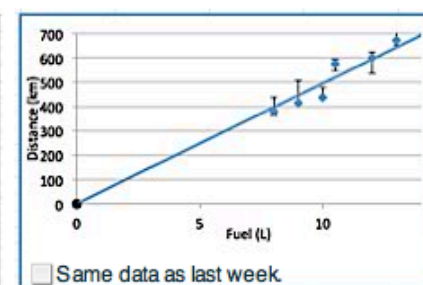
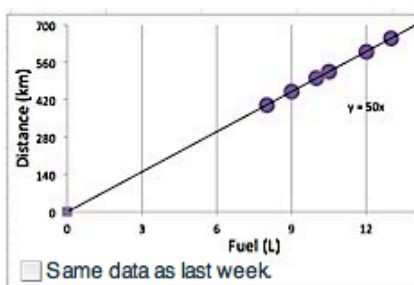
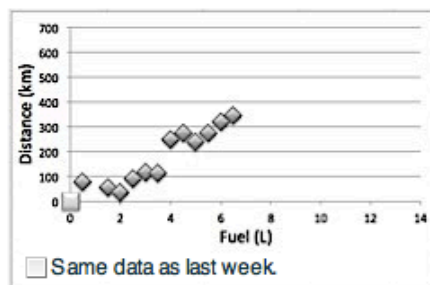


- Recall data and equation
 - *Which of the following graphs were used last week?*
 - *What was the equation from last week?*
 - *What were the features?*

Last week we asked you to use four graphs to invent a method for finding the uncertainty in the slope of an unweighted best-fitting line with a fixed intercept at the origin. Before we discuss slope uncertainty in a more general form, we would like to spend a minute recalling some of the information presented last week.

Done

Given that the first graph (below) was one of the four given last week, which of the remaining graphs show the same data that was presented to you last week? Please check all that apply.

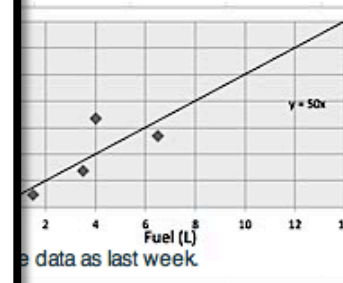
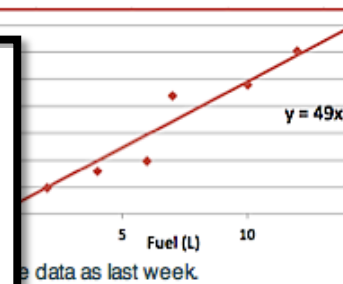


WITHOUT looking in your books, what was the formula for calculating the uncertainty in the slope of an unweighted best fitting line with an intercept fixed at zero? Please use the equation editor below to recreate the equation to the best of your ability.

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What were the three features involved in determining the uncertainty in the slope of an unweighted best fitting line with an intercept fixed at zero?

Done



Behaviours

- Log files of student actions throughout invention process
 - Where do they spend their time during invention activities?
 - How many solutions do they create?
 - How much evaluating are they doing?
 - Other questions I can't even think of?

Next round of research questions?

- Motivation orientation
 - Does motivation correlate to invention performance?
 - How do invention activities affect motivation over the year?
- Case-studies
 - How do students use invention activities?
 - What self-regulated learning strategies are they using on their own?
 - What SRL strategies do we support?
 - What SRL strategies should we be supporting?