Scientific sensemaking: Intellectual resources that predict content learning

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Scientific Sensemaking

- What is Scientific Sensemaking (SSM)?
- Instrument Design
- Describe this Study
- Results
- Next Steps
What comprises Scientific Sensemaking?

Scientific sensemaking is an individuals’ capacity to engage with science learning as a sensemaking activity.

- **Asking Good Questions**: Identifies investigable problems and generates appropriate questions from them
- **Designing Investigations**: Designs experiments appropriate to a research question with relevant control of variables
- **Interpreting Data in Text, Tables and Graphs**: Extract information from data to identify relevant information
- **Seeking Mechanistic Reasoning**: Extracts relevant evidence; interprets and analyzes data accurately and with intention
- **Engaging in Argumentation about Science Ideas**: Understands the relationship between claims, evidence, and reasoning; Constructs mechanistic explanations of phenomena.
- **Understanding the changing Nature of Science**: Understands how science as a discipline works; knows that science is both a body of knowledge and a process.
Challenges

Content problem
- Science sensemaking is deep integration of content and practices of science
- But not interested in measuring content knowledge per se (unlike the NGSS)
- Students vary too much in prior content instruction

Effort Problem
- Sensemaking requires effort: what is the incentive for spending the effort?

Length Problem
- Reasoning items significant learner time; long assessments are hard to use in research and a disaster in evaluation work

Longitudinal measurement problem
- Pre/post or longitudinal designs require new items; how made equivalent?
Our Strategy

Content problem
- Scenarios that leverage common, rather than rare content

Effort Problem
- Charismatic Megafauna (Dolphins, Monkeys, Eagles, etc.)

Length Problem
- Sample sub-constructs lightly

Longitudinal measurement problem
- Different scenarios
- Link scenarios to each other
Elijah wonders if the temperature of the water makes a difference in how much dolphins play. Which question is the best to ask to investigate this?

A. Do dolphins play in warm water?
B. Which other animals live in the same part of the ocean as dolphins?
C. Do dolphins live in warm or cold water?
D. Do dolphins play more when the water is warm or cold?

You are wondering which type of dolphin eats the most amount of food per day. What is the best evidence you could get to answer this question?

A. You observe how much Bottlenose dolphins eat in a day.
B. You find a scientific study that says that Bottlenose dolphins swim over 18 miles per hour.
C. You measure the amount of food eaten by 50 dolphins of each type.
D. You ask several people who work at an aquarium to estimate how much food each type of dolphin eat.
A group of students are observing dolphins in a cove. Maria and Celia both think:

- Dolphins are affected most by the amount of noise.
- Many dolphins left the cove when there was a lot of noise.

**Maria says:** *Dolphins cannot hear each other when there is a lot of noise, so they leave.*

**Celia says:** *Dolphins leave because it is noisy, so when there is a lot of noise they leave.*

Whose reasoning for why the dolphins leave the cove is more scientific?

A. Celia because she repeats the important idea.
B. **Maria** because she explains how the noise causes a problem.
C. Celia because she uses data collected from a study.
D. Maria because I would also leave if my environment was noisy.
Research Questions

- What are the scale’s psychometric properties?
- What is Scientific Sensemaking’s Relationship to Learning?
- What is the stability of Scientific Sensemaking over time?
# Malleable Factors (ALES 2014)

## 2014-2015

<table>
<thead>
<tr>
<th>6th + 8th grade</th>
<th>Fall</th>
<th>Spring</th>
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</table>

### Fidelity / Activity Logs
- Begin: ~3 times
  - Mid: ~3 times
  - End: ~3 times

### Activation
- Begin
  - Mid
  - End

### Family Background
- Begin

### Prior/Recent Experiences
- Begin
  - Mid

### *Content knowledge*
- Pre
  - Post

### Engagement
- ~3 times
  - ~3 times

### Choice Preferences
- Begin
  - End

### Career Likelihood
- Begin
  - End
## Results: Relationship to Learning

<table>
<thead>
<tr>
<th></th>
<th>Model 1: Baseline</th>
<th>Model 2: Pre-test</th>
<th>Model 3: Sensemaking</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>$\beta$</td>
<td>$p$</td>
<td>$\beta$</td>
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<tr>
<td>Knowledge Pre-Test Score</td>
<td>0.51</td>
<td>&lt;0.001</td>
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<td>Scientific Sensemaking</td>
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<td>REML</td>
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<td>$R^2$ marginal</td>
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<td>$R^2$ conditional</td>
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<tr>
<td>ICC</td>
<td>0.17</td>
<td>0.06</td>
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</table>
Results: Relationship to Learning

No Influence of Subject Matter

- Adjusted Post-test z-scores
- Scientific Sensemaking
- Biology Classroom
- Non-Biology Classroom
Results: Relationship to Learning

No difference by Classroom Dialog (Student vs. Teacher Centered)

No difference by Curriculum Type (Hands-on vs. Textbook)
Results: Relationship to Learning

No difference by grade, Sex, Race/Ethnicity
## Results: Relationship to Learning

Sub-constructs predicting Learning

<table>
<thead>
<tr>
<th>Sub-construct</th>
<th># of Items per Sub-construct</th>
<th>Sensemaking Sub-Constructs</th>
<th>$\beta$</th>
<th>$p$</th>
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<td>Asking Questions</td>
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Two Takeaways

- Students who can engage in scientific sensemaking are better positioned to learn scientific content.

- It is possible to measure scientific practices in content through relatively short pencil & paper instruments.
Future Goals

- **Link other versions** (Dolphins, Monkeys, Eagles, Smoking, & Planets)

- **Test out additional NGSS practices** (e.g. Developing and Using Models)

- **Develop an instrument that feels less like school**
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Questions?

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