Data Explorations in Ecology: Secondary Students’ Knowledge, Skills and Attitudes Towards Data

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• Student participants
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Next Generation Science Standards – Science Practices

BOX 3-1

PRACTICES FOR K-12 SCIENCE CLASSROOMS

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Data Literacy Skills

The data don’t predict a tsunami with **absolute** certainty.
I still say we wait.
I don't think we can ignore these data; after all, his book was on the best-seller list.
Data Exploration in Ecology Project (DEEP)

- PD focused on data literacy
- Teachers in SE and central NY
- Curricular materials on local problems (fracking, salt, etc.) blending work with first and second hand data
- Collected data on 14 MS and HS teachers and 356 students
- ½ students in 7th or 9th grade classes – basic environmental science, earth science, Living Environment
- ½ students in 10th-12th grade classes – advanced environmental science, marine science, research, electives
DEEP Research Questions

1) What data activities are common in secondary schools and what factors support and constrain teachers’ implementation of instruction that targets data literacy skills?

2) What are secondary students’ knowledge, skills, and attitudes toward data?
# Classroom Data Practices

<table>
<thead>
<tr>
<th>More Common</th>
<th>Less Common</th>
</tr>
</thead>
<tbody>
<tr>
<td>First hand data collection</td>
<td>Processing, manipulating, analyzing data</td>
</tr>
<tr>
<td>Making representations</td>
<td>Discussing strengths and limits of different representations</td>
</tr>
<tr>
<td>Discussing sources of variability</td>
<td>Reasoning about variability</td>
</tr>
<tr>
<td>Constructing arguments based on evidence</td>
<td>Critiquing arguments based on evidence</td>
</tr>
</tbody>
</table>
Teacher Described **Constraints** to Implementation

- **Time**: 32%
- **Student KSAs**: 22%
- **DE Skills**: 18%
- **Curriculum integration**: 10%
- **Access to Data**: 9%
- **Access to resources**: 6%
- **Content knowledge**: 3%

of 243 total utterances
Teacher Described Supports to Implementation

- 19% - Student KSAs - data collection
- 16% - Participation in a PLC
- 14% - Working with Cary scientists
- 12% - Engagement in PD activities
- 10% - PD provider support
- 10% - Curriculum materials
- 8% - Teacher learning
- 7% - Involvement in module development
- 4% - Timing of the PD workshops

of 157 total utterances
Teacher Described Motivations to Teach Data Exploration

- 24% of 62 total utterances
  - DE makes science lessons more authentic
- 23%
  - DE is interesting or enjoyable for students
- 15%
  - DE skills are important
- 11%
  - Teacher learning
- 3%
  - Teaching about DE is interesting or enjoyable
- 11%
  - Being treated like a professional

of 62 total utterances
DEEP Research Questions

1) What data activities are common in secondary schools and what factors support and constrain teachers’ implementation of instruction that targets data literacy skills?

2) What are secondary students’ knowledge, skills, and attitudes toward data?
Identifying and Interpreting Data Representations

<table>
<thead>
<tr>
<th>Identification</th>
<th>7th and 9th (n=194)</th>
<th>10th – 12th (n=162)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify bar graphs</td>
<td>99%</td>
<td>99%</td>
</tr>
<tr>
<td>Identify line graphs</td>
<td>91%</td>
<td>93%</td>
</tr>
<tr>
<td>Identify scatter plot graphs</td>
<td>80%</td>
<td>84%</td>
</tr>
<tr>
<td>Identify basic trends when shown basic line graphs</td>
<td>91%</td>
<td>97%</td>
</tr>
<tr>
<td>or scatter plots</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identify data tables and bar graphs with error bars</td>
<td>24%</td>
<td>67%</td>
</tr>
</tbody>
</table>

*Students across grades are familiar with, and able to identify basic trends in certain kinds of data representations but they have a limited range of representations they are comfortable with.*
Understanding Variability

<table>
<thead>
<tr>
<th></th>
<th>7th and 9th (n=302)</th>
<th>10th – 12th (n=318)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify variability in data</td>
<td>72%</td>
<td>95%</td>
</tr>
<tr>
<td>Provide a correct description or definition of variability</td>
<td>54%</td>
<td>82%</td>
</tr>
<tr>
<td>List two possible causes or sources of variability</td>
<td>64%</td>
<td>82%</td>
</tr>
</tbody>
</table>

*Across grade levels the most common descriptions of variability included variability as changes or fluctuations in data (32%), differences in data (23%) and a measure of deviation from the average (8%).
# Implications of Variability in Data

<table>
<thead>
<tr>
<th></th>
<th>7&lt;sup&gt;th&lt;/sup&gt; and 9&lt;sup&gt;th&lt;/sup&gt; (n=302)</th>
<th>10&lt;sup&gt;th&lt;/sup&gt; – 12&lt;sup&gt;th&lt;/sup&gt; (n=318)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No idea of why it is important to think about variability in a set of data</td>
<td>41%</td>
<td>31%</td>
</tr>
<tr>
<td>Variability influences confidence in a claim</td>
<td>4%</td>
<td>14%</td>
</tr>
<tr>
<td>Variability is an indication of potential measurement error</td>
<td>4%</td>
<td>18%</td>
</tr>
<tr>
<td>Variability shows a change in general</td>
<td>12%</td>
<td>4%</td>
</tr>
<tr>
<td>Variability provides more information in general</td>
<td>10%</td>
<td>8%</td>
</tr>
<tr>
<td>Variability in data provides evidence of natural variations in a system.</td>
<td>18%</td>
<td>20%</td>
</tr>
</tbody>
</table>
# Evaluating Claims Based on Evidence

<table>
<thead>
<tr>
<th></th>
<th>7&lt;sup&gt;th&lt;/sup&gt; and 9&lt;sup&gt;th&lt;/sup&gt; (n=302)</th>
<th>10&lt;sup&gt;th&lt;/sup&gt; – 12&lt;sup&gt;th&lt;/sup&gt; (n=318)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cite data when evaluating a claim supported by a chart or graph</td>
<td>14%</td>
<td>42%</td>
</tr>
<tr>
<td>Cite data when evaluating claims made in an article that references data</td>
<td>9%</td>
<td>32%</td>
</tr>
<tr>
<td>• Insufficient amount of data to support the claims made</td>
<td>7%</td>
<td>20%</td>
</tr>
<tr>
<td>• Data were not relevant to the claim</td>
<td>1%</td>
<td>4%</td>
</tr>
<tr>
<td>• Insufficient amount of information about the data</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>• Insufficient data to show causation</td>
<td></td>
<td>10%</td>
</tr>
<tr>
<td>• Cite source bias</td>
<td></td>
<td>4%</td>
</tr>
</tbody>
</table>
In General ...

• Most students can define and identify variability, and list potential sources, with HS > MS

• Few students can explain why variability is important for answering a scientific question, or making a claim or a prediction.

• Students in both the lower and upper grades have data exploration knowledge and skills that are useful in helping them evaluate claims based on the data provided, but they seldom use these skills in the (citizenship based) contexts where they are most pertinent.
An Evidence- and Reasoning-Based Critique and Inquiry Framework
An Evidence- and Reasoning-Based Critique and Inquiry Framework

Design & Implement

Manipulate

Analyze & Summarize

Filter & Synthesize

Communicate & Apply

DATA

EVIDENCE

INFORMATION

EVIDENCE-BASED INQUIRY

EVIDENCE-BASED CRITIQUE

REASONING

Questions

Raw Data

Derived Data

Representations

Arguments

Filters & Synthesis

Action
1. Identify variability
2. Understand sources of variability
3. Reduce variability
4. Calculate indices, etc.
5. Choose data

1. Understand implications of variability for inferences
2. Identify and create different types of representations
3. Choose appropriate representation
4. Interpret representations
5. Evaluate representations

1. Use multiple types of data
2. Choose data to support claims
3. Combine evidence appropriately
4. Critique choices and synthesis of evidence in arguments

1. Construct an argument with evidence & reasoning
2. Communicate argument
3. Make evidence based recommendation

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**DATA**
- Raw Data
- Derived Data
- Representations

**EVIDENCE**
- Filters & Synthesis
- Arguments

**INFORMATION**

**EVIDENCE-BASED INQUIRY**

**REASONING**

**EVIDENCE-BASED CRITIQUE**

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**Questions**

**Design & Impl.**

**Manip.**

**Analysis & Summary**

**Synthesis**

**Commun. & Apply**

**Action**
DEEP Research Instruments and Curricular Materials

https://sites.google.com/site/teachingecosystemliteracy/Home/deep
1. Look at the temperature data at different times within EACH of the three periods. Compare them and then decide which period shows the most variability. Explain why you picked that period.

2. Please list at least two possible causes or sources of this variability
Factors Influencing Teachers’ Self-Efficacy Regarding Teaching About Data

- Teachers’ understanding of how to implement DE focused instruction: 61% of 54 total utterances
- Teachers’ comfort and confidence in their own DE knowledge and skills: 39% of 54 total utterances
Nuh-uh. Some guy on Twitter just said you're wrong.
<table>
<thead>
<tr>
<th>Agree/Strongly agree</th>
<th>10th - 12th</th>
<th>7th and 9th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working with data improved my...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working with data improved my...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The lessons made more sense to me...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working with data in this class made...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The lessons took longer to finish...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working with data did not improve...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working with data is not important...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The lessons were harder to...</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Student Attitudes Toward Data Exploration Practices