Tools Guiding Our Work

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Storyline Diagram

• Introduced to us by Dr. Brian Reiser from Northwestern (Thanks Brian!)
• Provides a framework for coherence of unit
  – Coherence to overarching unit phenomena
  – Coherence in narrative flow of unit
  – Coherence towards a culminating performance expectation
• Do students know WHY they are doing each activity in the unit?
Storyline Template (Reiser, 2014)

Driving question

Phenomena + Question
Phenomena + Question
Phenomena + Question
Revisit Driving question

Investigate and build knowledge through practices

Analyze data, explain [PE₁]
Explain, argue, model [PE₂]
Explain argue, model [PE₃]
Culminating PE

Incrementally Build Models That Explain Phenomena

Initial model
Add to/revise model
Add to/revise model
Final consensus model
Anchoring Phenomena

Qualities of a good phenomenon
- A puzzling observable event or process
- Generates student interest and questions
- Intersects with numerous PEs
- Can be explored through science and engineering practices
Phenomena Examples (Reiser, 2014)

• After a rainfall, puddles of water on the street dry up on a sunny day. How and why did the water “dry up?”

• My brother and I both look like my parents. I know we got DNA from our parents. But if we both got DNA from the same parents, why do my brother and I look different from each other?

• NOT: How does evaporation / inheritance happen?
Our Working Phenomenon

Human beings are disrupting the ecosystem in cities by planting trees, with the intention of enhancing the benefits to human beings and other organisms.
Design Challenge: What kinds of trees should we plant and where to increase biodiversity and maximize benefits to human beings and other organisms?

<table>
<thead>
<tr>
<th>Phenomenon/Question</th>
<th>Engage in Practices</th>
<th>What Students Can Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why should I care about trees?</td>
<td>Students plan and carry out investigations, analyze and interpret data, and use simulations to explore the interdependence of trees with other organisms in their environment.</td>
<td>How changes in tree cover affect biotic and abiotic elements in an ecosystem.</td>
</tr>
<tr>
<td>How many trees can we grow in Denver and where can we grow them?</td>
<td>Students will analyze and interpret data from tree rings, construct explanations, and engage in argument from evidence about the resources trees need, and the limitations.</td>
<td>How availability of resources and competition affect carrying capacity of trees and other organisms in an ecosystem.</td>
</tr>
<tr>
<td>How do trees affect the air we breathe?</td>
<td>Students analyze data and construct and use models of the role of trees within the cycling of carbon in an ecosystem.</td>
<td>How changing the number of trees in an ecosystem affects the air we breathe and changes habitats and feeding relationships in a food web.</td>
</tr>
<tr>
<td>What kind of trees would provide the most benefit to the ecosystem?</td>
<td>Students plan and conduct investigations of trees in their local area and solve the problem presented in the design challenge, using their models of an urban ecosystem to explain their solution.</td>
<td>What trade-offs are involved in planting trees in terms of benefits to the environment; What species of tree will increase biodiversity while minimizing potential negative consequences.</td>
</tr>
</tbody>
</table>

Human beings are disrupting the ecosystem in cities by planting trees, with the intention of enhancing the benefits to human beings and other organisms.
Practices in Isolation

Lesson 1
Lesson 2
Lesson 3
Lesson 4
Lesson 5
Components in Isolation ≠ NGSS

From NRC Framework (2012)

• “The overall objective is that students develop both the facility and the inclination to call on these practices, separately or in combination, as needed to support their learning and to demonstrate their understanding of science and engineering” (p.49)
STEM Teaching Tools

This site has tools that can help you teach science, technology, engineering and math (STEM). We are currently focused on supporting the teaching of the Next Generation Science Standards (NGSS). Each tool is focused on a specific issue and leverages the best knowledge from research and practice. Under the News section, you can learn a bit more about how you might use them. This article provides background on this effort.

Current Highlight from the Tools section

[Tweets]

Tiffany Lee
@TiffanyPhD
6h
Sharing ideas & getting feedback about @STEMTeachTools with #cscubed @STEMequality @philipbell
pic.twitter.com/3jaQTQppru

Retweeted by STEM Teaching Tools
Practices Should Not Stand Alone: How to Sequence Practices in a Cascade to Support Student Investigations
Cascade of Practices

From Bell et al. (2012)

• “The practices do not operate in isolation, and we argue that part of giving students opportunities to participate in authentic scientific and engineering work is ensuring that they can experience firsthand the interrelatedness of these practices—as an unfolding and often overlapping sequence, or a cascade” (p.18)
Cascade of Practices

Lesson 1

Lesson 2

Lesson 3

Lesson 4

Lesson 5

PE
Cascade of Practices

- Asking Questions
  - Lesson 1
- Computational Thinking
  - Lesson 2
- Modeling
  - Lesson 3
- Planning and Carrying Out an Investigation
  - Lesson 4
- Analyzing and Interpreting Data
  - Lesson 5
- PE
1. Raw Data
   - Digital Photos
     - geotagged
     - Provided Set
     - User contributed
     - Mixture of scale in photos but focusing on organism
     - Relationships between photos
   - Field Survey
     - Prepared potential organisms
     - Training

2. Image Processing
   - Identify/Cataloging
     - Organisms
     - Abiotic factors
     - Potential relationships
       - [co-occurrence]
       - [direct causation]
   - Labeling
   - Statistical analysis
   - Potential relationship
   - X teaches
   - 60
   - 120
   - 20
   - 6

3. Data Cleaning and Validation
   - Misidentification
     - Organism
     - Factors
   - Compare to comparable angle by difference
   - Cross team data check
   - Net cost
   - What happens under change

4. Building Static Model
   - Lucid Chart
     - Dynamic What-if Model Variations
   - Characterize interaction
   - [Diagrams]
Section 4 Student Workflow

(1) Data Collection
- Collect raw data
- Digital Photos - Geotagged
- 2 Photo Sources - Provided Set - User submitted
- Focus on - Organisms - Relationships - Abiotic factors
- Field survey pre-populated with potential organisms
- Annotate photos
- Training

(2) Data Analysis
- Process data
- Parse raw images
- Identify/Catalog - Organisms - Relationships - Abiotic factors
- Consult field guide resource(s)
- Denote potential relationships based on evidence from: - Co-occurrence data - "Direct" observation

(3) Data Validation
- Check for misidentification of - Organisms - Relationships - Abiotic factors
- Cross-team checks
- Flag issues for debate
- Validate relationships using - Co-occurrence frequency - "Direct" observation - Lit review resources - Theory from model board

(4) Build Model
- Integrate data
- Create concept map of ecosystem (Lucidchart)
- Scenario testing of phenomena (invasive species)

(5) Use Model
- Dynamic NetLogo
- What if…?
- Input new tree, gives output for proposal
- Characterize interactions
## Next Iteration of Workflow

### Cascade of Practices

<table>
<thead>
<tr>
<th>Student Phase of Investigation Cycle/&quot;Cascade of Practices&quot;</th>
<th>Lesson Number</th>
<th>Driving Question</th>
<th>What Students Will Figure Out</th>
<th>How They'll Figure It Out</th>
<th>What the Phenomenon Is</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define Overarching Unit Question</td>
<td>1.1</td>
<td>Why should we care about trees?</td>
<td>Things that they know already and need to figure out to solve the challenge; Benefits of trees to people that are a priority to the class that they want to maximize to solve the challenge</td>
<td>Students ask questions related to the possible impacts of planting trees to modify the environment; Students further define the engineering problem by identifying reasons why they care about trees and relate them to the challenge</td>
<td>Cities are ecosystems where human activity is constantly modifying the environment, such as through building and construction, redirecting waterways, and consumption of energy for cars, heating, and cooling.</td>
</tr>
<tr>
<td>Define Question/Problem</td>
<td>1.2</td>
<td>What effect do trees have on the air temperature around us?</td>
<td>Cities are much hotter than surrounding areas, and the pattern on maps shown at the regional and neighborhood scale shows that where there are more buildings, it's hotter, while where there are more trees, the temperature is cooler.</td>
<td>Students analyze data from graphs and maps to identify land cover patterns associated with the Urban Heat Island effect.</td>
<td>THE &quot;URBAN HEAT ISLAND&quot; PATTERNS OF HEAT/COOL ARE OBSERVABLE AT NEIGHBORHOOD AND REGIONAL LEVEL LEVEL</td>
</tr>
</tbody>
</table>

### Driving Questions

- Why should we care about trees?
- What effect do trees have on the air temperature around us?
- Why is it cooler where there are trees than where there are buildings and roads?

### What Students Figure Out

- What Students DO (SEP)
- Phenomenon
Reminder of Resources

Cascade of Practices
stemteachingtools.org/brief/3
Reminder of Resources

Storyline Tool
tinyurl.com/StorylineTool


Reiser, B. (2014, April). Designing coherent storylines aligned with the NGSS for the K-12 classroom. *NSELA Conference*. Presentation in Boston, MA.