Tools Guiding Our Work

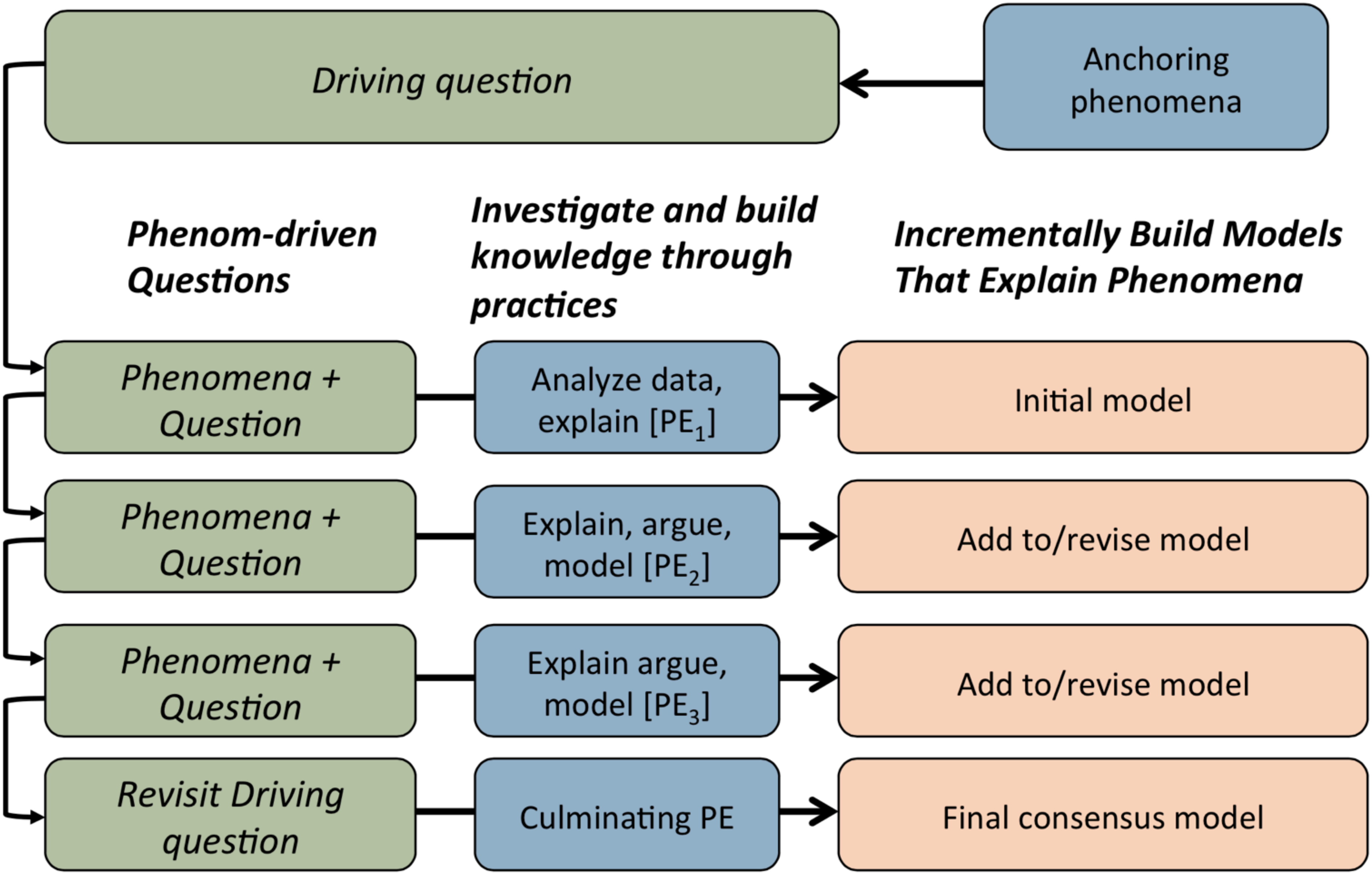
Samuel Severance
University of Colorado Boulder

This work was supported by a grant from the National Science Foundation (Award #1147590). The opinions expressed herein are those of the authors and do not necessarily reflect those of the NSF.

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)



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)

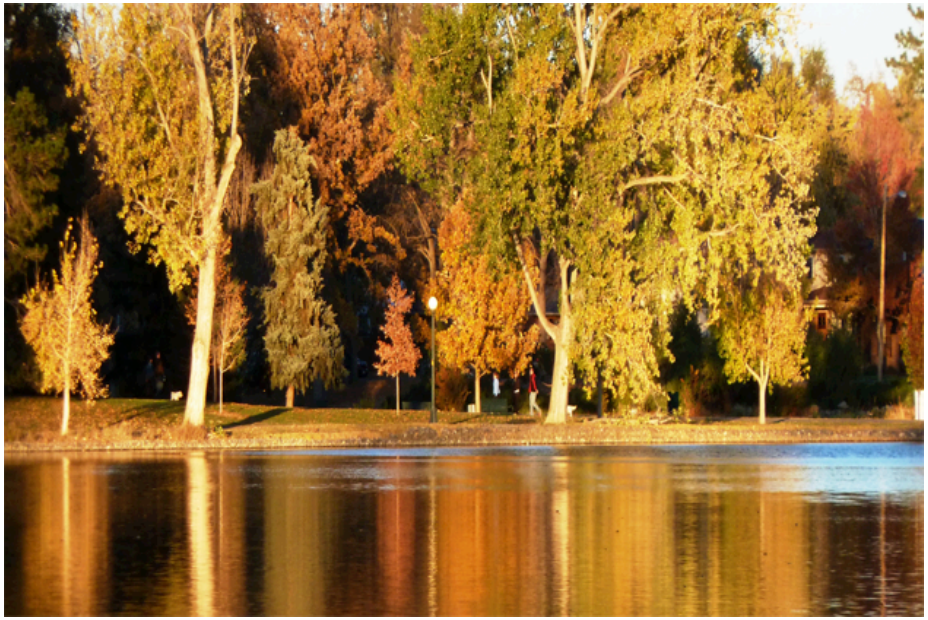
- After a rainfall, puddles of water on the street dry up on a sunny day. How and why did the water “dry up?”

- 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?

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

Phenomenon/Question	Engage in Practices	What Students Can Explain
Why should I care about trees?	Students plan and carry out an investigations, analyze and interpret data, and use simulations to explore the interdependence of trees with other organisms in their environment.	How changes in tree cover affect biotic and abiotic elements in an ecosystem.
How many trees can we grow in Denver and where can we grow them?	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.	How availability of resources and competition affect carrying capacity of trees and other organisms in an ecosystem.
How do trees affect the air we breathe?	Students analyze data and construct and use models of the role of trees within the cycling of carbon in an ecosystem.	How changing the number of trees in an ecosystem affects the air we breathe and changes habitats and feeding relationships in a food web.
What kind of trees would provide the most benefit to the ecosystem?	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.	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.

Practices in Isolation

Practices

Lesson 1

Practices

Lesson 2

Practices

Lesson 3

Practices

Lesson 4

Practices

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

stemteachingtools.org

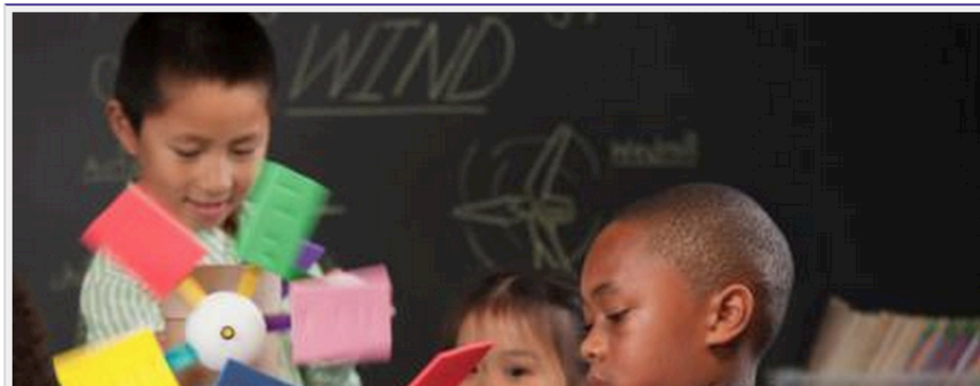
Teaching Tools for Science, Technology, Engineering and Math (STEM) Education

HOME TOOLS NEWS ABOUT

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

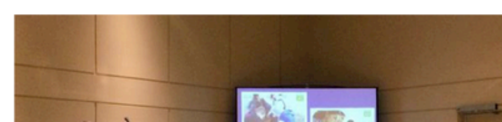


Tweets Follow

Tiffany Lee @TiffanyPhD 6h

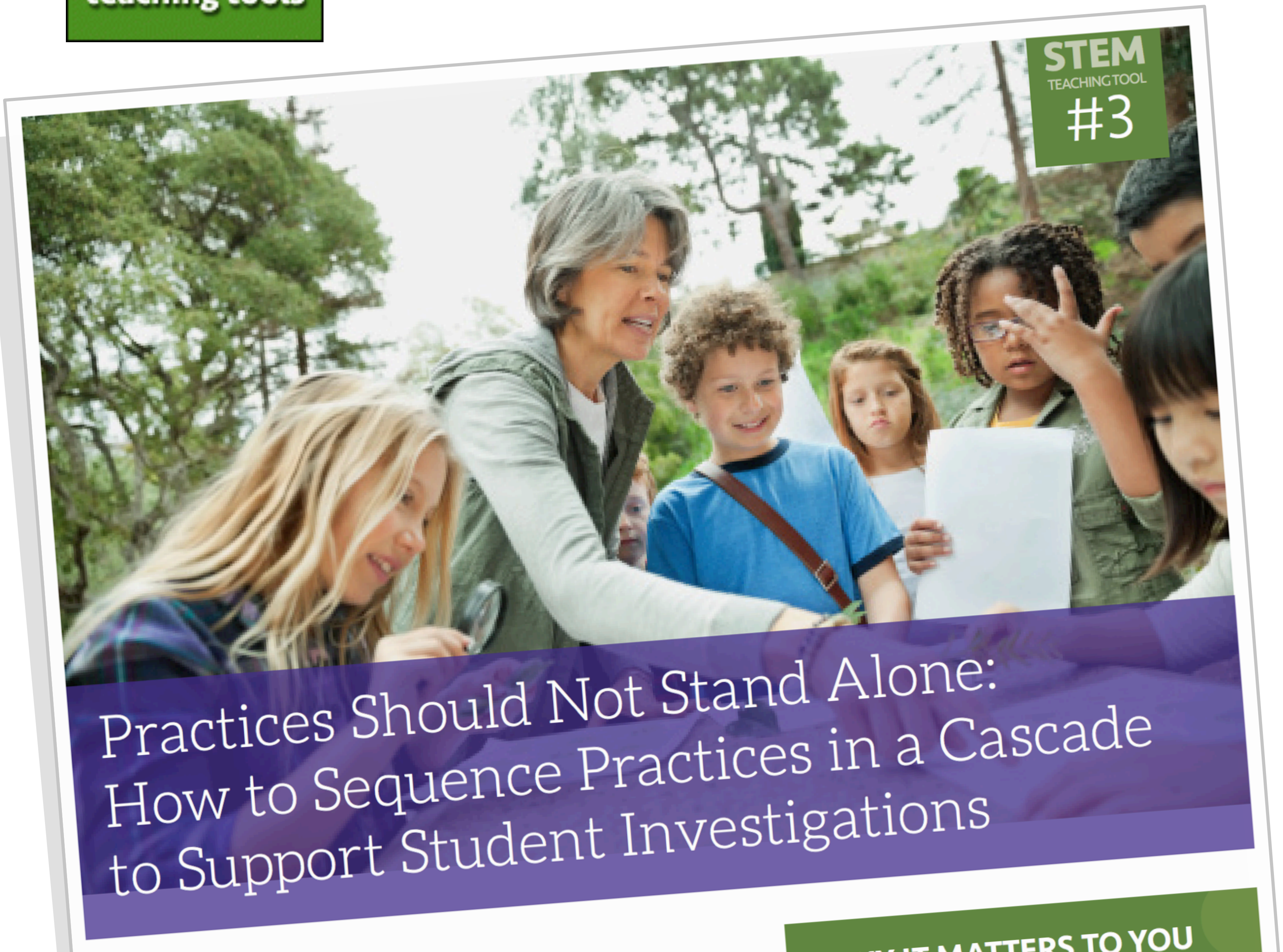
Sharing ideas & getting feedback about @STEMTeachTools with #cscubed @STEMequality @philiplbell pic.twitter.com/3jaQTQppru

Retweeted by STEM Teaching Tools



STEM
teaching tools

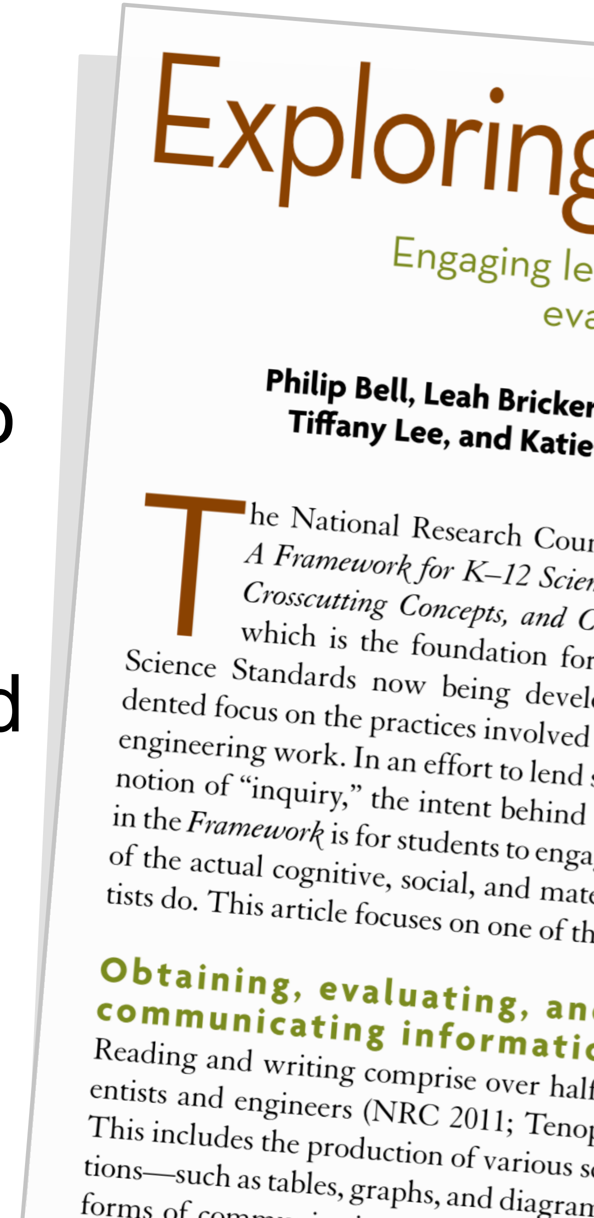
stemteachingtools.org/brief/3



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)



Explorin

Engaging le
eva

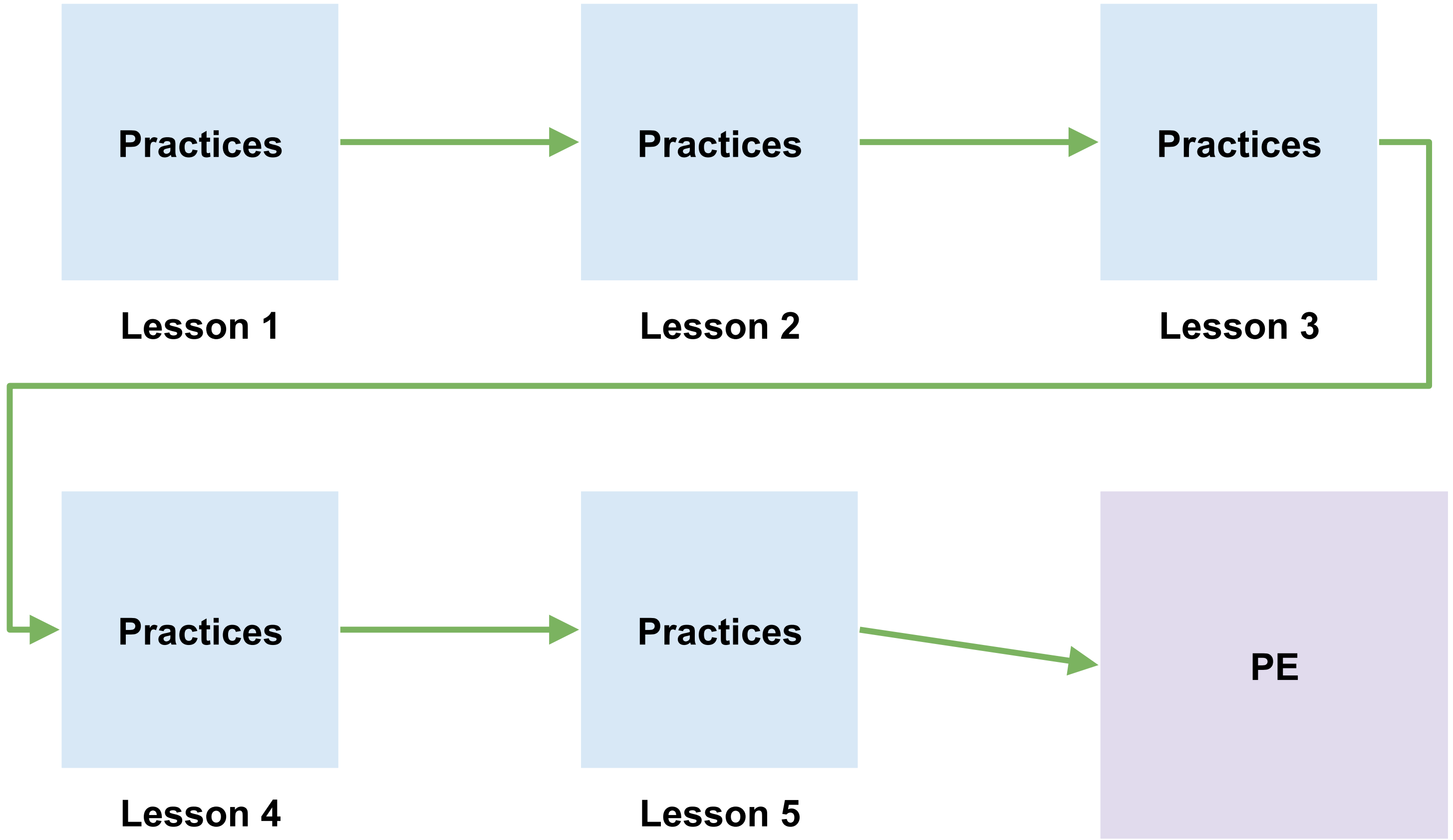
Philip Bell, Leah Bricke
Tiffany Lee, and Katie

The National Research Cou
A Framework for K–12 Scie
Crosscutting Concepts, and C
which is the foundation fo
Science Standards now being devel
dented focus on the practices involved
engineering work. In an effort to lend
notion of “inquiry,” the intent behind
in the *Framework* is for students to enga
of the actual cognitive, social, and mat
tists do. This article focuses on one of th

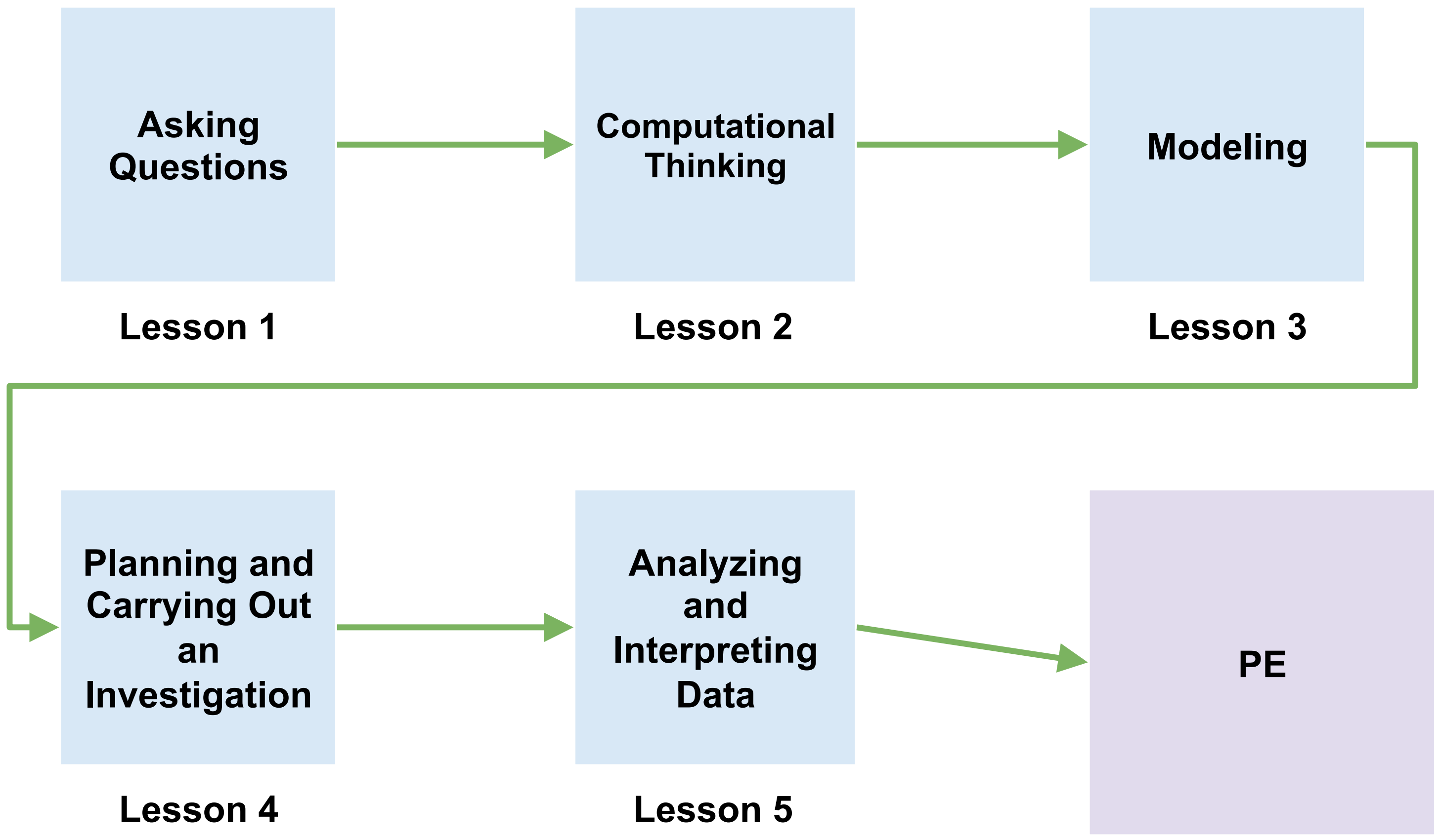
Obtaining, evaluating, an
communicating informati

Reading and writing comprise over hal
entists and engineers (NRC 2011; Teno
This includes the production of various s
tions—such as tables, graphs, and diagra
forms of comm

Cascade of Practices



Cascade of Practices



① Raw Data

Digital Photos
- geo tagged

* Provided Set
* User-contributed

Mixture of scale in photos but focusing on organisms

* Relationships between photos

Field Survey
Prepopulated w/potential organisms

Annotator
Training

② Image Parsing

*

Identify / Cataloging
- organisms
- abiotic factors [notable]

- Potential relationships
[co-occurrence]
[direct observation]

8 teachers
× 60

$$\frac{120}{6} = 20$$

③ Data Cleansing Validation

Mis identification
- organisms
- factors

Compare to comparable & flag big differences

Cross team data check

. . . .

Potential Relationships

Identify most numerous co-occurrence

low frequency co-occurrences

Model Based
theory
lit review
observation

④ Building Static Model

Lucid Chart

⑤ Dynamic What if Model Verification

Net Logo
- What happens under change

Characterize interaction

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

Driving Questions

What Students Figure Out

What Students DO (SEP)

Phenomenon

CASCADE OF PRACTICES		STORYLINE ELEMENTS			
				How They'll Figure It Out	
Student Phase of Investigation Cycle/"Cascade of Practices"	**Lesson Number**	**Driving Question**	**What Students Will Figure Out**	**(What Students DO/Science and Engineering Practice)**	**What the Phenomenon Is**
Define Overarching Unit Questior	1.1	Why should we care about trees?	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	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.	***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.***
Define Question/Problem	1.2	What effect do trees have on the air temperature around us?	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.	Students analyze data from graphs and maps to identify land cover patterns associated with the Urban Heat Island effect.	**THE "URBAN HEAT ISLAND" PATTERNS OF HEAT/COOL ARE OBSERVABLE AT NEIGHBORHOOD AND REGIONAL LEVEL LEVEL**
		Why is it cooler where there are trees than where there are buildings and roads?		Students plan and carry out an investigation of effects of different surfaces on temperature in the	

Reminder of Resources


STEM
TEACHING TOOL
#3

ld Not Stand Alone:
nce Practices in a Cascade
dent Investigations

WHY IT MATTERS TO YOU

Teachers should intertwine and sequence multiple scientific practices in their teaching in ways that integrate the conceptual ideas of science.

ces in the NGSS
and be integrated
ss-cutting

STEM teaching tools

stemteachingtools.org

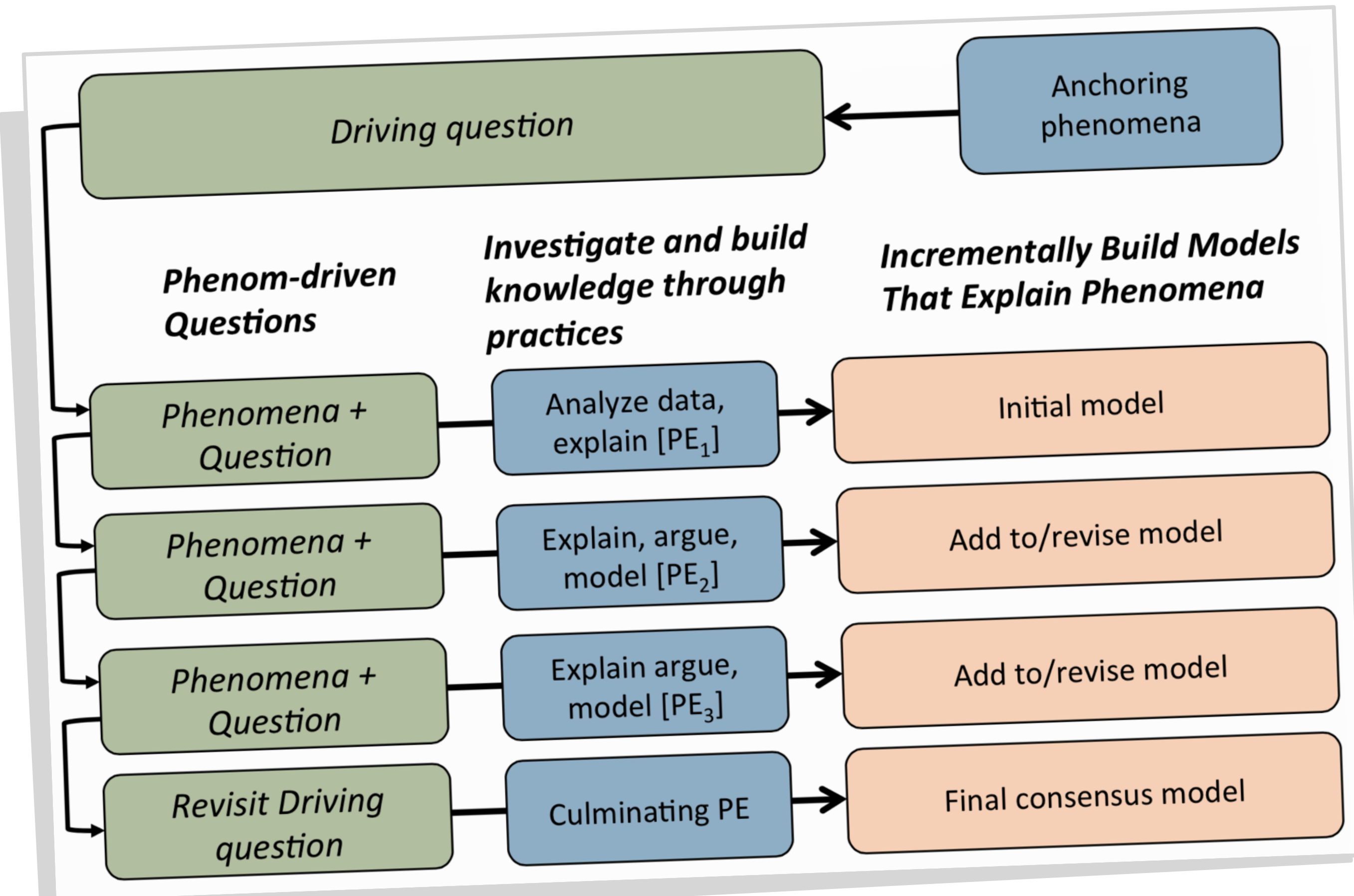
Cascade of Practices

stemteachingtools.org/brief/3

Reminder of Resources

Storyline Tool

tinyurl.com/StorylineTool



Brian Reiser

References

Bell, P., Bricker, L., Tzou, C., Lee, T., & Horne, K. Van. (2012). Exploring the Science Framework: Engaging learners in scientific practices related to obtaining, evaluating, and communicating information. *Science Scope*, *79*(8), 31–37.

National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington DC: National Academies Press.

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