# *Re-conceptualizing the Scientific Inquiry Geoscience Education Literature in Context of the K-12 Next Generation Science Standards (NGSS) Practices*

*Nancy A. Price- Department of Geology- Portland State University*

- Asking Questions & Defining Problems
- Developing & Using Models
- Planning & Carrying Out an Investigation
- Analyzing & Interpreting Data
- Using Mathematics & Computational Thinking
- Constructing Explanations & Designing Solutions
- Engaging in Argument from Evidence
- Obtaining, Evaluating, & Communicating Information

## ***Driving Questions for the Literature Review:***

1. **How can we re-conceptualize the past literature on "scientific inquiry" in the face of the new terminology of the NGSS?**

   ***Developing & Executing Methods:***
   - *Conceptual Framework from which to consider the Practices?*
   - *Defining (comprehensive) search terms.*
   - *What parameters with which to evaluate existing literature?*

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2. **Which Practices are well studied/understudied in the Earth & Space Sciences literature?**

   **Example Practice:** *Developing & Using Models*

   **Execution of Methods: Emergent Themes for the Earth & Space Sciences:**
   - *Articulating "aspects of inquiry" that are characteristic of each Practice in the Earth & Space Sciences*
   - *Definition of Practice Pairs as "inquiry paths" in the Earth & Space Sciences*
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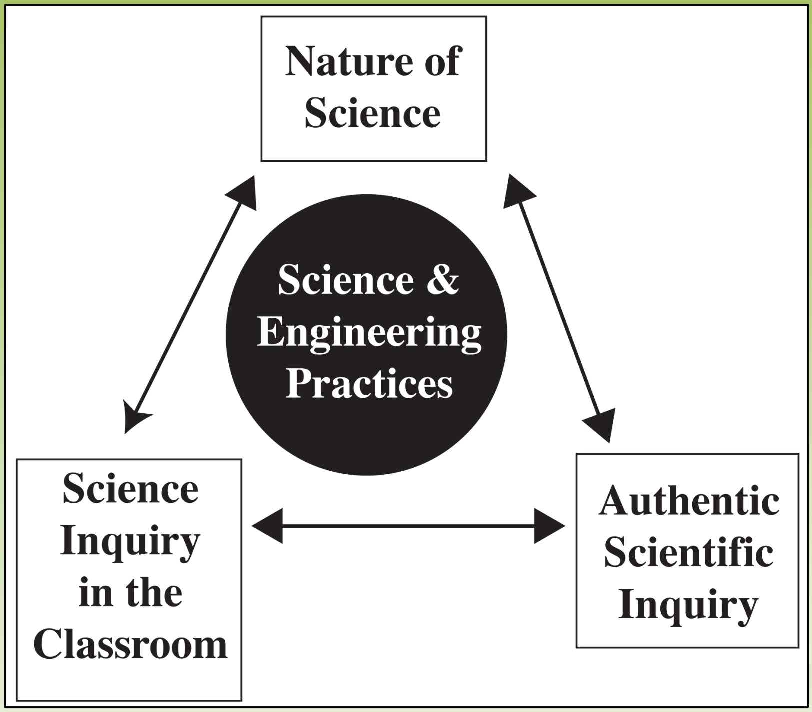
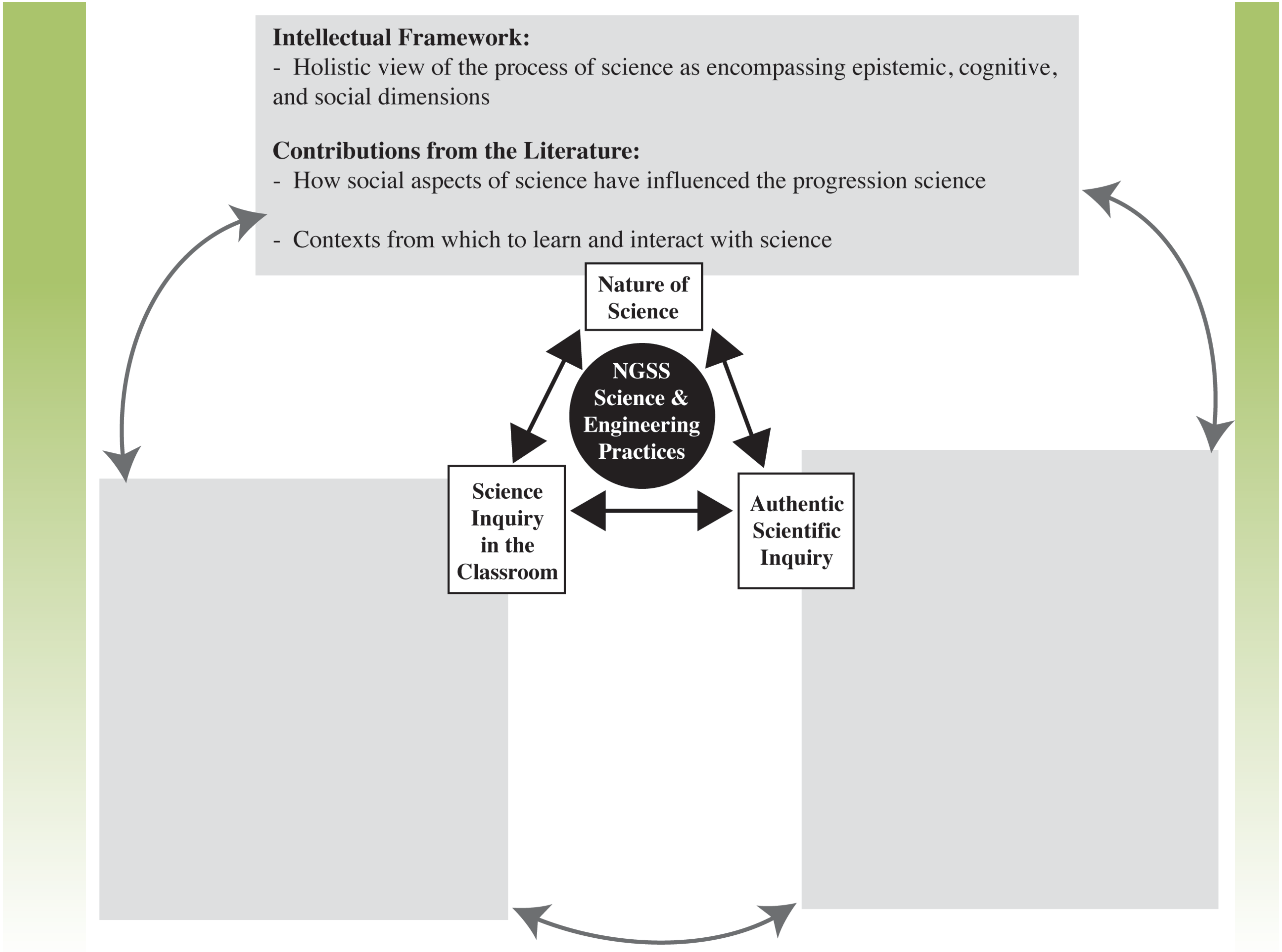
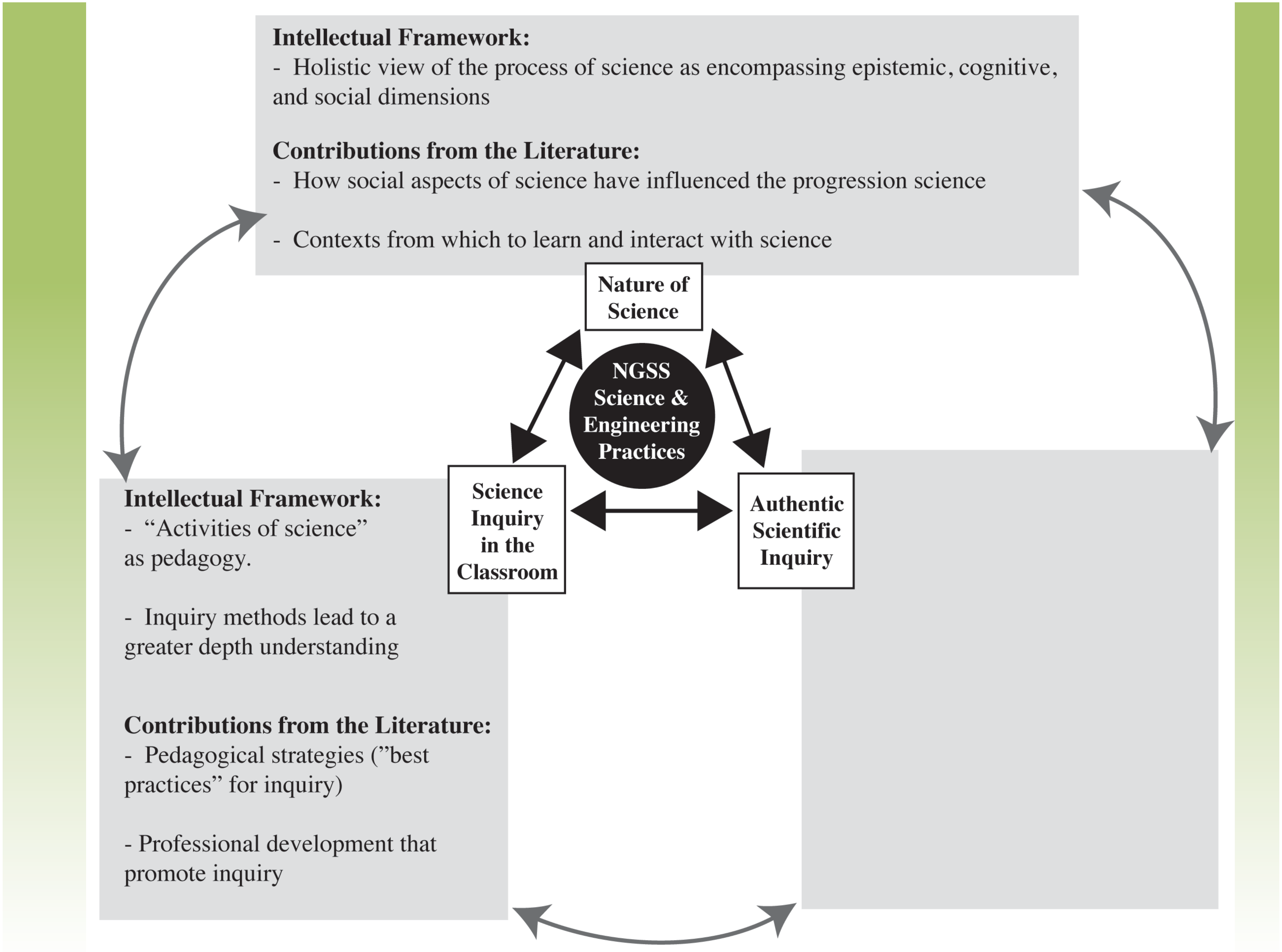



Intellectual Framework:
- Holistic view of the process of science as encompassing epistemic, cognitive, and social dimensions
Contributions from the Literature:
- How social aspects of science have influenced the progression science
- Contexts from which to learn and interact with science
Nature of Science
NGSS Science & Engineering Practices
Science Inquiry in the Classroom
Authentic Scientific Inquiry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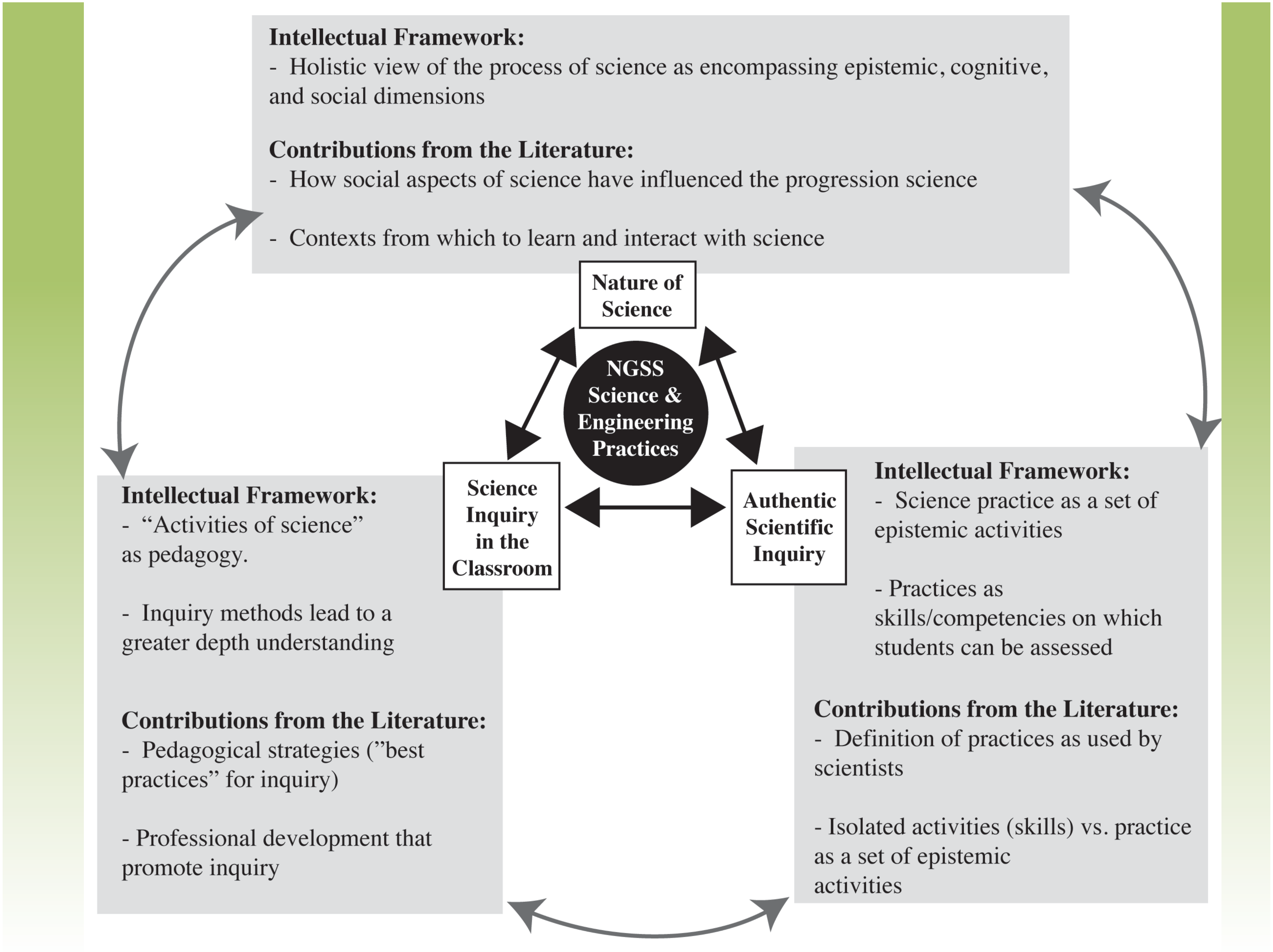
- "Activities of science" as pedagogy.
- Inquiry methods lead to a greater depth understanding
Contributions from the Literature:
- Pedagogical strategies ("best practices" for inquiry)
- Professional development that promote inquiry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Intellectual Framework:
- Science practice as a set of epistemic activities
- Practices as skills/competencies on which students can be assessed
Contributions from the Literature:
- Definition of practices as used by scientists
- Isolated activities (skills) vs. practice as a set of epistemic activities

1. **How can we re-conceptualize the past literature on "scientific inquiry" in the face of the new terminology of the NGSS?**
    - *Defining (comprehensive) search terms.*

| Practice: | Search Terms | Topics Encountered in the Search |
|---|---|---|
| Developing and Using Models | Models*; Developing Models; Using Models; Modeling; Model-Based; Model-Based Conceptual Change; Conceptual Model; Scientific Models; Causal Models; Systems Model<br><br>*Note: Search terms as outlined above were combined with "Geosciences"; "Geology", &"Earth Sciences"* | mental models; misconceptions/alternative conceptions/preconceptions; conceptual change; analogical thinking; visualization; spatial thinking; student conceptions of deep time; systems thinking; model-based learning; gesturing; concept mapping; Sun-Moon-Earth system; watershed models; computational models; virtual environments; Google Earth/GIS as an educational tool; constructivist learning |

- Started with terminology of the Next Generation Science Standards, then added search terms based on the nature of results.
- For each search, results were reviewed for ~15-20 pages (depending on the relevancy of the results) and continued until little-to-no novel/relevant results.

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    - *What parameters with which to evaluate existing literature?*

## *A. Type of Article*

| | | | | |
|---|---|---|---|---|
| **Instructional Treatment Research Study** | **Reflective Study of Classroom Products/Student Work** | **Survey Study** | **Commentary** | **Literature Review** |

| | | | |
|---|---|---|---|
| **Outline of a Framework or Construct** | **Program Evaluation** | **Description/ Evaluation of Classroom Activity** | **Other Research Study** |

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## *B. Grade Level*

| | | | | | | |
|---|---|---|---|---|---|---|
| **Elementary** | **Middle School circa 11 yr, 5/6 grade** | **High School** | **K-12** | **Intro College/ University** | **Pre-service/In-service Teacher Education** | **N/A or not stated** |

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***C. Practice***

**- Asking Questions & Defining Problems**

**- Developing & Using Models**

**- Planning & Carrying Out an Investigation**

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**- Obtaining, Evaluating, & Communicating Information**

**- Relevant, but not directly connected to a Practice**

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***D. Learning Target***

A. Develop/Use a model to represent an event or object
B. Compare models to find similarities and/or differences
C. Develop/Use a model to represent differences in amounts, scales
D. Develop/Use a model to represent an abstract/unobservable concept
E. Develop/Use a model to describe phenomena
F. Develop/Use a model to make a prediction
G. Develop/Use a model to explain relationships
H. Describe/Recognize the limitations of models
I. Evaluate/Revise a Model
J. Describe/Use a Model to represent systems or parts of a system

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2. **Which Practices are well studied/understudied in the Earth & Space Sciences literature?**

    **Example Practice:** *Developing & Using Models*

    **Execution of Methods: Emergent Themes for the Earth & Space Sciences:**
    - *Articulating "aspects of inquiry" that are characteristic of each Practice in the Earth & Space Sciences*
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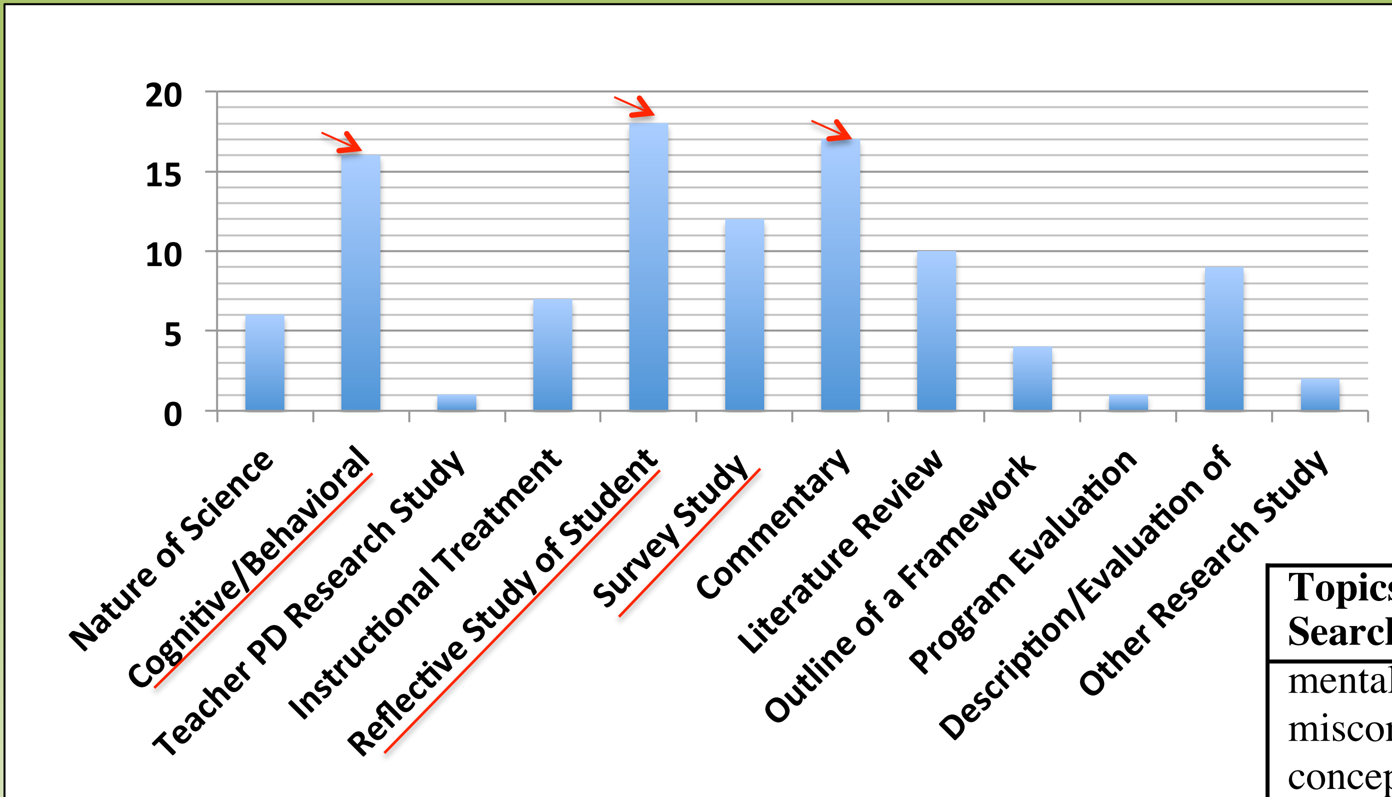
**Example Practice:** *Developing & Using Models*




- Papers resulting from search terms for "Developing & Using Models" (N= 73)
- *Some papers fit into multiple categories (e.g. Literature Review & Outline of a Framework)*

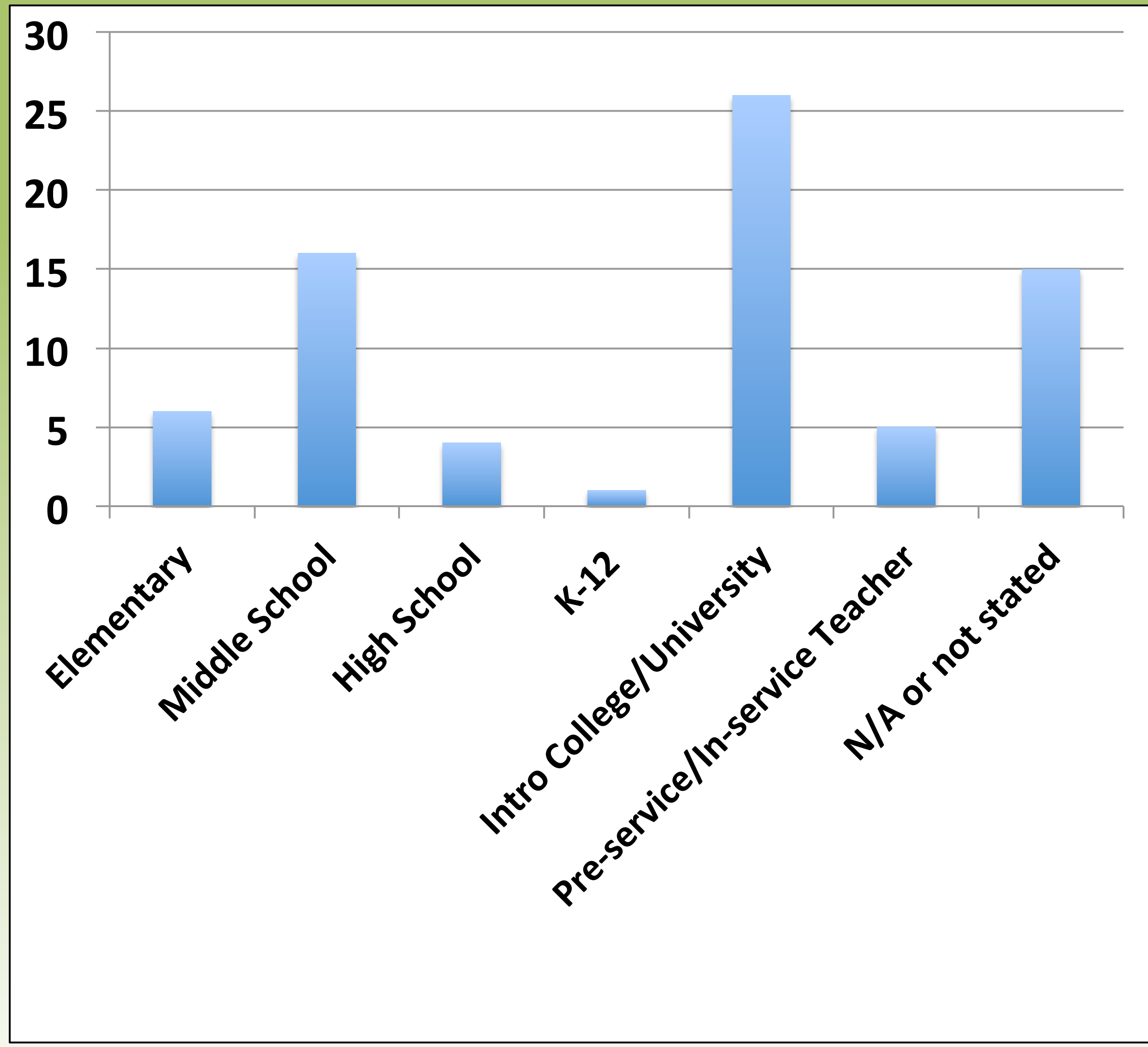
| Topics Encountered in the Search |
|---|
| mental models; misconceptions/alternative conceptions/preconceptions; conceptual change; analogical thinking; visualization; spatial thinking; student conceptions of deep time; systems thinking; model-based learning; gesturing; concept mapping; Sun-Moon-Earth system; watershed models; computational models; virtual environments; Google Earth/GIS as an educational tool; constructivist learning |

**Example Practice:** *Developing & Using Models*

- Elementary & Middle School are well represented, but there is much to learn from studies of 2/4yr colleges/universities.

- How well do teachers understand models?

- Overlap between Paper Type & Grade Level for *Developing & Using Models*?
  - *Elementary Levels and Cognitive*
    *=*
    *Sun, Moon, Earth System*



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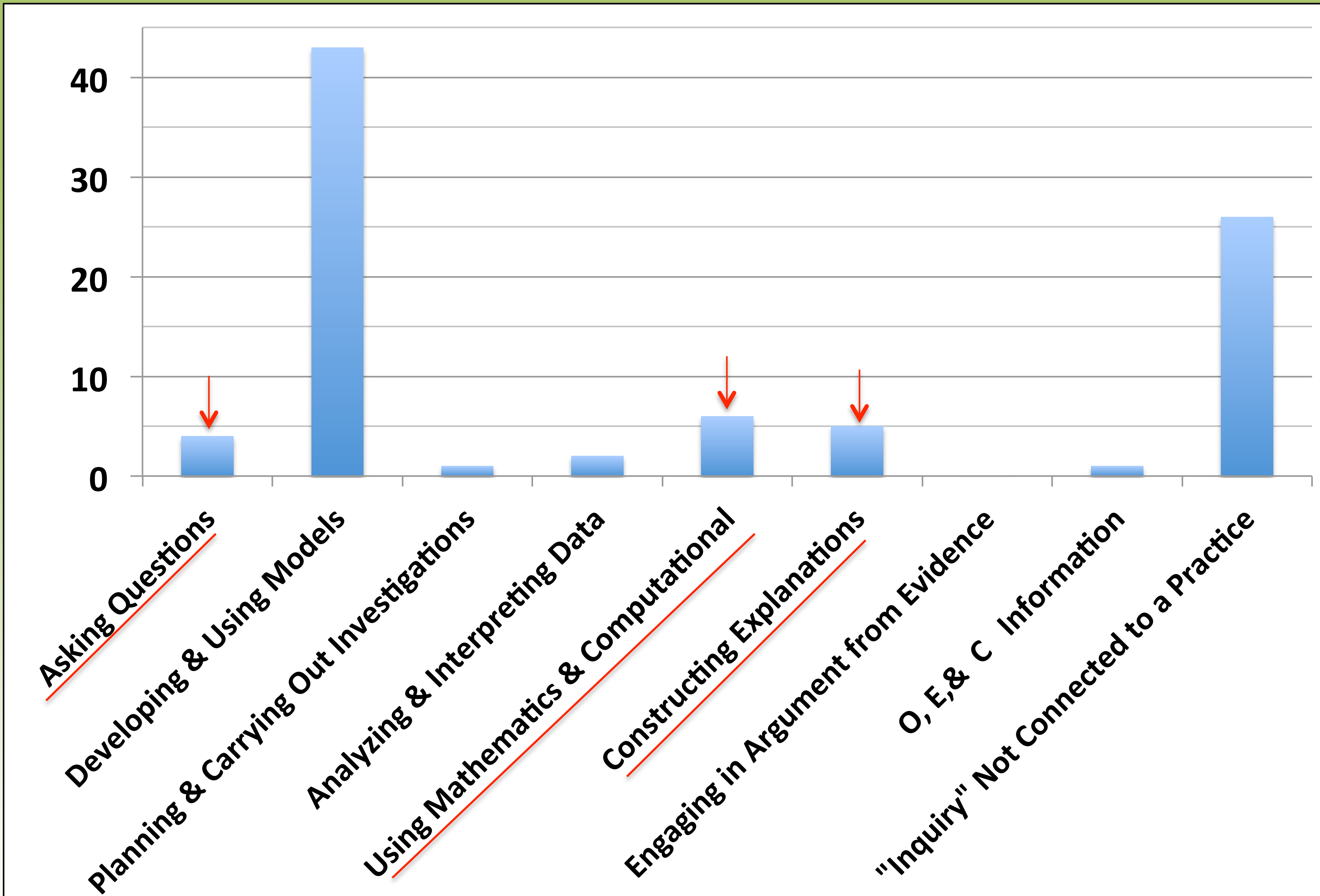
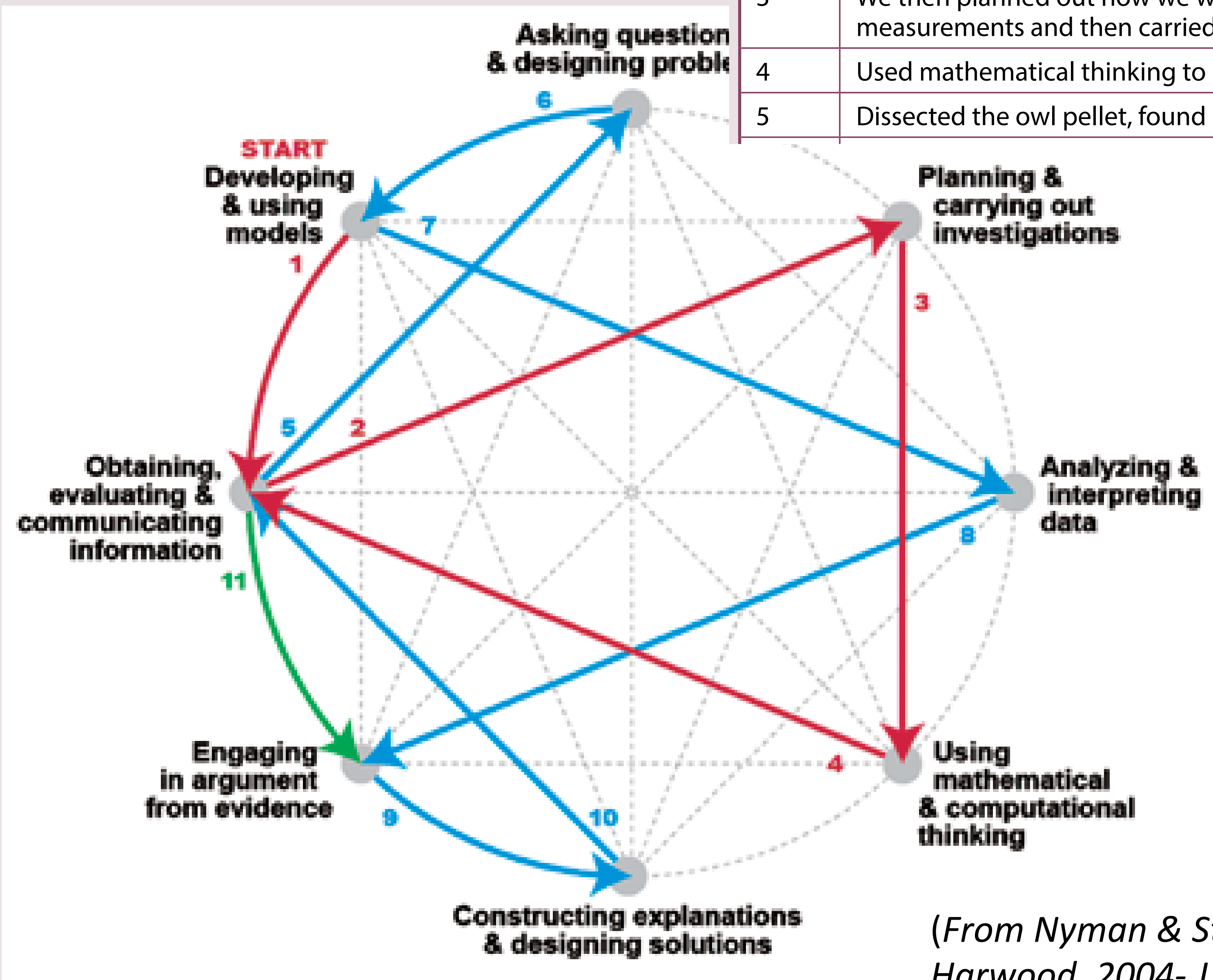


## FIGURE 6

**Science practice model annotated for owl |**

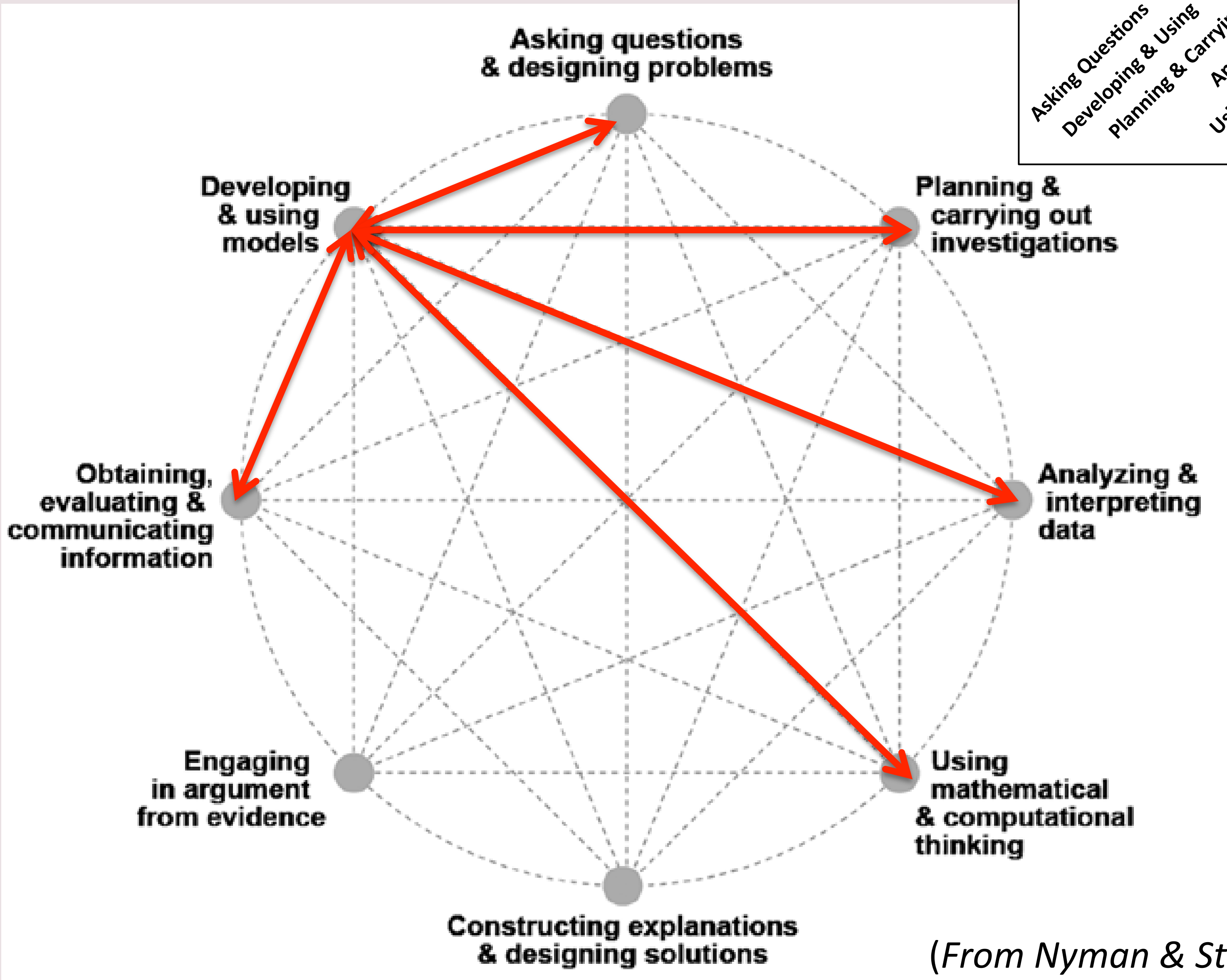
| Steps | Specifics of practice |
|---|---|
| 1 | Made a food web model. |
| 2 | We got our owl pellets and he gave us questions. |
| 3 | We then planned out how we were going to make all the measurements and then carried it out. |
| 4 | Used mathematical thinking to make measurements. |
| 5 | Dissected the owl pellet, found bones, and other information. |

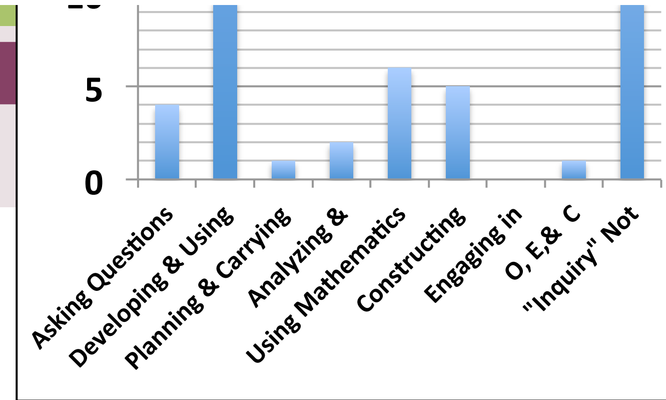



(*From Nyman & St. Clair, 2016,; after Harwood, 2004- J of Col. Sci. Teaching*)

## FIGURE 5

**Science practice model.**

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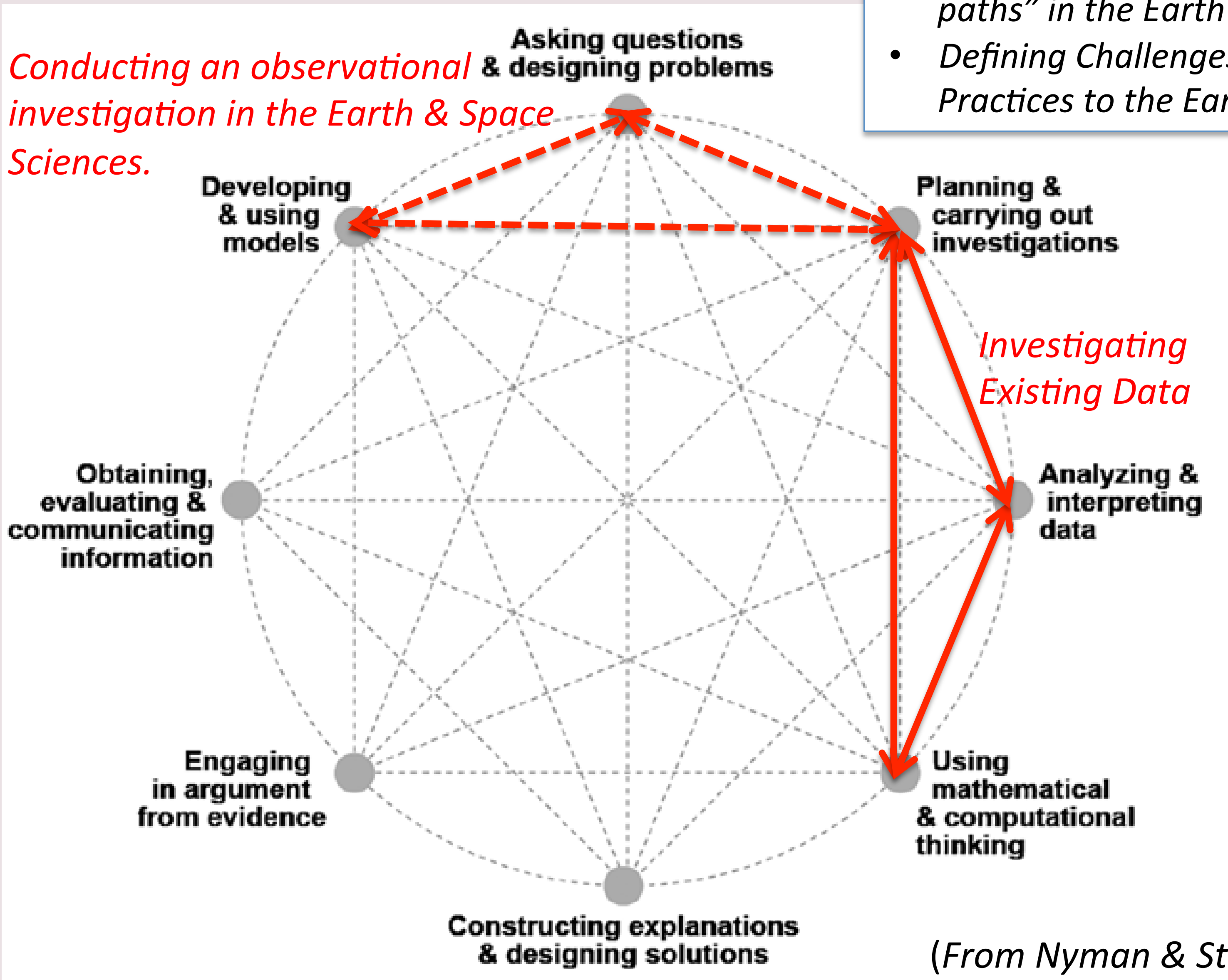


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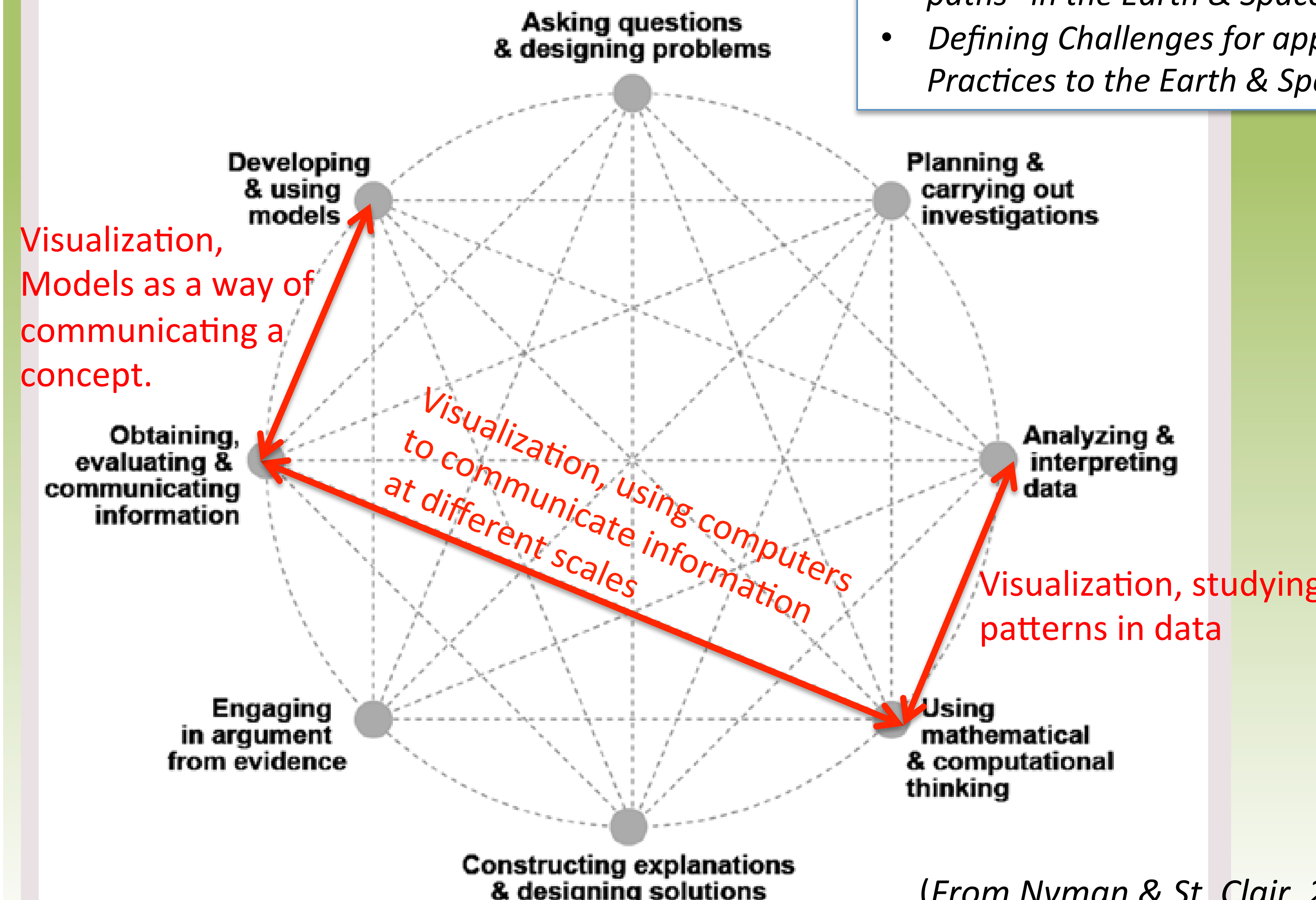


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- Develop/Use a model to **represent an event or object**
  - *Sun-Moon-Earth System*
- Develop/Use a model to **represent differences in amounts, scales.**
  - *regional to micro- scales*
- Develop/Use a model to **represent an abstract/unobservable concept.**
  - *systems thinking*
  - *change over time*

A. **Develop/Use a model to represent an event or object**

B. Compare models to find similarities and/or differences

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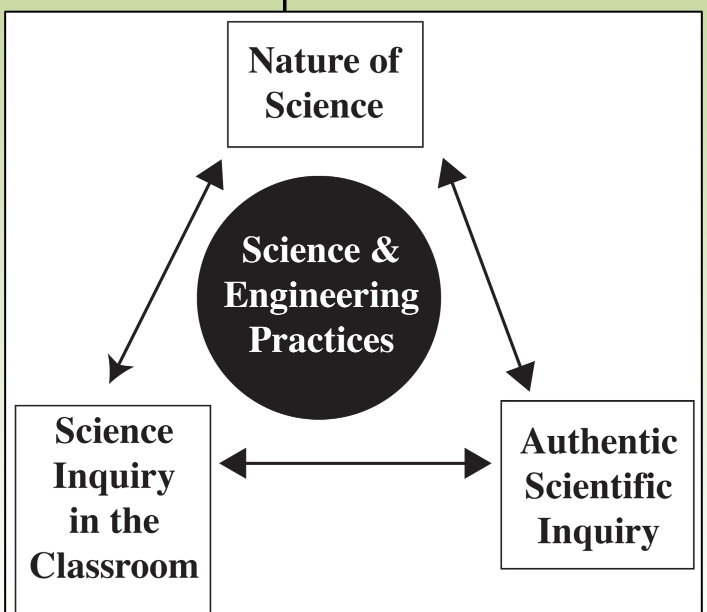
| Practice: | Aspects Unique to the Nature of Science of the Geosciences | Aspects Unique to the Geosciences as Science Practice | Aspects Relevant for Teaching Geoscience Topics |
|---|---|---|---|
| Developing and Using Models | - Geoscientists investigate concepts that span a wide range of spatial and temporal scales that are commonly understood and discussed using models.<br><br>- Geologists used models to make sense of abstract and/or unobservable objects and phenomena. | - Analog models are used as physical representations of the Earth that are used in making predictions and investigating ideas.<br><br>- Geoscientists represent Earth systems as models that are used as a common framework guiding all aspects of inquiry.<br><br>- Representations of causal relationships in systems models are predictions that can be tested. | - Analogies and Analog models can be used as tools for building knowledge of abstract/unobservable geoscience concepts by explicitly mapping the ways that the two examples are related<br><br>- Model revision is important for students to move from representation to incorporation of causal mechanism.<br><br>- Analog models allow students to manipulate the spatial and temporal scales of the model to study Earth processes |



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Comments,
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