Teaching and Learning with the Science and Engineering Practices

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Agenda

- Overview and Introductions
- Activity 1: Science Lesson
- Presentation: Introduction to the 8 Practices
- Activity 2: Critique Science Lesson

BREAK

- Presentation: Introduction to the Practices Continuum
- Activity 3: Analyze video
- Activity 4: Analyze Vignette
- Next Time – Plan to Try out a Practice
- Conclusions and Discussion

PowerPoint at: http://www.katherinelmcneill.com

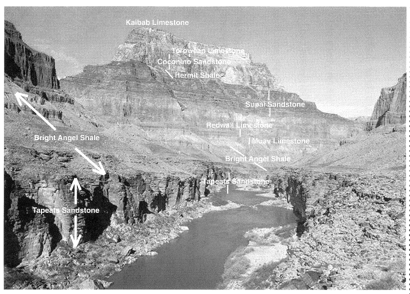
Introductions

- Introduce yourself to the group
  - Name
  - School or Institution
  - Position (e.g. grade level and topics)

Goals for 5 Meetings

- Develop a deeper understanding of the 8 science practices in NGSS
  - Clarifying definitions of each practice
  - Explore the relationships between the 8 practices
- Develop strategies to adapt existing curriculum to align more closely with the science practices
  - Identify challenges around adapting (both student challenges and lesson design challenges)
  - Develop strategies for designing lessons

Activity #1 - Science Lesson



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TRANSPARENCY No.

Activity #1 - Science Lesson

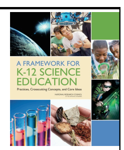
TRANSPARENCY No. 12

GRAND CANYON ROCK AGES

- **Geologists have determined that Earth is probably about 4.5 billion years old.**
- **The Kaibab Limestone is about 250 million years old.**
- **The Muav Limestone is about 530 million years old.**
- **Under the Muav Limestone is a layer of shale and then a layer of sandstone.**
- **The oldest rock layer in the Grand Canyon, found far under the Muav Limestone, is at least 1.7 billion years old.**

QUESTION: What events or processes do you think caused these rock layers to form?

Science Practices (NRC, 2012)



- Why science practices?
  - "…students cannot fully understand scientific and engineering ideas without engaging in the practices of inquiry and the discourses by which such ideas are developed and refined. At the same time, they cannot learn or show competence in practices except in the context of specific content." (p. 218)
- Why "practices" and not inquiry?
  - "We use the term 'practices' instead of a term such as 'skills' to emphasize that engaging in scientific investigation requires not only skill but also knowledge that specific to each practice." (p. 30)

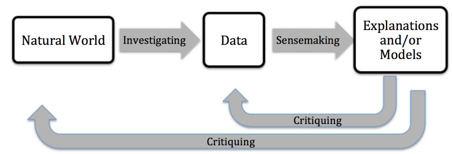
Science Practices

1. Asking questions and defining problems
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 and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating and communicating information

Practices Work Together

- "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 interrelateness of these practices – as an unfolding and often overlapping sequence, or a cascade." (Bell et al., 2012, p. 2)

8 Science Practices



Investigating Practices	Sense-making practices	Critiquing Practices
1. Asking questions	2. Developing and using models	7. Engaging in argument from evidence
3. Planning and carrying out investigations	4. Analyzing and interpreting data	8. Obtaining, evaluating and communicating information
5. Using mathematical and computational thinking	6. Constructing explanations	

Science Practices

1. Asking questions and defining problems
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Resources:
- http://ngss.nsta.org
- www.SciencePracticesLeadership.com

Asking Questions

- *Scientific questions lead to explanations of how the natural world works and can be empirically tested using evidence.*

- Example Standard
  - Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion (3-PS2-3)
  - In a Classroom - How does the size of a magnet affect the number of paper clips it can pick up?

Developing and using models

- *A model is an abstract representation of phenomena that is a tool used to predict or explain the world. Models can be represented as diagrams, 3-D objects, mathematical representations, analogies or computer simulations.*
- Example Standard
  - Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. (MS-LS3-1)
  - In a Classroom - Students create a model of a strand of DNA. They then alter the base pairs (letters) to simulate a mutation. Students use their model to explain how changes in base pairs leads to changes in the proteins constructed.

Planning and carrying out investigations

- *An investigation is a systematic way to gather data about the natural world either in the field or in a laboratory setting.*
- Example Standard
  - Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. (MS-ESS2-5)
  - In a Classroom - Students conduct an investigation using hot red water and cold blue water to observe the ways the water does and does not interact, similar to air masses.

Analyzing and interpreting data

- *Analyzing and interpreting data includes making sense of the data produced during investigations. Because patterns are not always obvious, this includes using a range of tools such as tables, graphs and other visualization techniques to make sense of the data.*
- Example Standard
  - Use observations to describe patterns of what plants and animals (including humans) need to survive. (K-LS1-1)
  - In a Classroom - Students use a class chart of what different animals eat and group the animals in different ways based on their food sources. Students discuss which animals would be affected if changes occurred to different food sources.

Using mathematics and computational thinking

- *Mathematical and computational thinking involves using tools and mathematical concepts to address a scientific question.*
- Example Standard
  - Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. (MS-PS3-1)
  - In a Classroom - Students create graphs of the data from an investigation about the relationship between a ball's mass and its speed down a ramp.

Constructing explanations

- *A scientific explanation is an explanatory account that articulates how or why a natural phenomenon occurs that is supported by evidence and scientific ideas.*
- Example Standard
  - Make observations to construct an evidence-based account that objects in darkness can be seen only when illuminated. (1-PS4-2)
  - In a Classroom - Students write explanations about why a light source is needed for a person to see an object. Students utilize evidence from an investigation as well as scientific ideas to explain why this occurs.

Engaging in argument from evidence

- *Scientific argumentation is a process that occurs when there are multiple ideas or claims (e.g. explanations, models) to discuss and reconcile. An argument includes a claim supported by evidence and reasoning as well as evaluates and critiques competing claims.*
- Example Standard
  - Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. (4-LS1-1)
  - In a Classroom -Students engage in a debate about whether a hypothetical organism could survive without several key anatomical features using evidence from common structures and their function in other animals.

Obtaining, evaluating, and communicating information

- *Obtaining, evaluating and communicating information occurs through reading and writing texts as well as communicating orally. Scientific information needs to be critically evaluated and persuasively communicated as it supports the engagement in the other science practices.*
- Example Standard
  - Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment. (5-ESS3-1)
  - In a Classroom - Students read in small groups three articles about different communities that have instituted plans to conserve energy. They evaluate the information to create a plan for how their own community can conserve energy.

8 Science Practices

Investigating Practices	Sense-making practices	Critiquing Practices
1. Asking questions 3. Planning and carrying out investigations 5. Using mathematical and computational thinking	2. Developing and using models 4. Analyzing and interpreting data 6. Constructing explanations	7. Engaging in argument from evidence 8. Obtaining, evaluating and communicating information

Activity #2: Critique Science Lesson

- In small groups, use the handout to critique the lesson you experienced earlier.
  - Which (if any) of the 8 practices occurred during the science lesson as it was enacted?
  - What evidence do you have for the occurrence of that science practice?

Activity #2: Critique Science Lesson

- Discussion
  - What practices did you see in the lesson the way it was taught? What was your evidence?
  - What practices were missing from the lesson?
  - Were there specific practices that were harder for your group to decide whether or not they occurred during the lesson? What made them more challenging?

BREAK

Continuum for the 8 Science Practices

- It takes time, support and practice for students to develop proficiency in the science practices.
- As teachers, we also have to think about and develop greater expertise around new ways of teaching science and supporting students

Continuum for the 8 Science Practices

	Level 1	Level 2	Level 3	Level 4
1. Asking questions	Teacher does not provide opportunities for students to ask questions.	Teacher provides opportunities for students to ask questions. Students' questions are not typically scientific questions (i.e., not answerable through the gathering of evidence or about the natural world).	Teacher provides opportunities for students to ask questions. Students' questions are both scientific and non-scientific questions.	Teacher provides frequent opportunities for students to ask questions. Students' questions are typically *scientific*.
2. Developing and using models	Teacher does not provide opportunities for students to create models.	Teacher provides opportunities for students to create or describe models. Students' models focus on describing natural phenomena rather than predicting or explaining the natural world.	Teacher provides opportunities for students to create or critique models. Student's models focus on predicting or explaining the natural world.	Teacher provides frequent opportunities for students to create *and* critique models. Students' models focus on predicting or explaining the natural world.

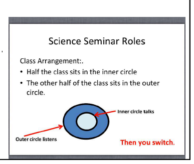
Classroom Culture Prioritizing Science Practices
Less ---More
Focused on scientific evidence
Connected to the natural world
Collaborative
Student-directed
Language-rich

Activity 3: Analyze Video

- You are going to watch a 5 minute clip from a 7th grade science lesson.
- After watching the video, you will talk with your group to use the continuum to analyze the video. You will decide:
  - What 2 or 3 practices do you feel that the video focused on?
  - For those practices, would you place them at a Level 2, 3 or 4?

7th Grade Example

- Context: Heredity Unit
- Question: What kind of allele causes the glowing trait in the cats?
- 3 Possible Claims
  - The allele for fluorescence is dominant.
  - The allele for fluorescence is non-dominant.
  - The allele for fluorescence is incompletely dominant.
- Evidence:
  - Punnett squares of different crosses of cats.
  - Data about crosses from jelly fish.
- Activity: Science Seminar



7th Grade Example

Discussion of Video

- What 2 or 3 practices do you feel that the video focused on?
- For those practices, would you place them at a Level 2, 3 or 4? Why?
- Were there specific practices that were harder for your group to decide whether or not they occurred during the video? What made them more challenging?

Activity 3: Analyze Vignette

- You are going to read a 3 page vignette from a 7th grade classroom. The vignette summarizes and provides some sample transcript over 2 days of instruction focused on the phases of the moon.
- After reading the vignette, you will talk with your group to use the continuum to analyze the example. You will decide:
  1. Which practices did not occur (Level 1)?
  2. What practices did occur? For those practices, would you place them at a Level 2, 3 or 4?

Discussion of Vignette

- What 2 or 3 practices do you feel that the video focused on?
- For those practices, would you place them at a Level 2, 3 or 4? Why?
- How was this lesson similar and different from the 7th grade videoclip? Why?

Annotated Vignette

- http://www.sciencepracticesleadership.com/exemplar---grade-7.html
- Intended Focus:
  - Developing and using models
  - Engaging in argument from evidence
  - Obtaining, evaluating and communicating information

Conclusions

- Engaging students in science practices enables them to develop a richer understanding of and ability to engage in science (moving beyond just memorizing facts).
- Each of the 8 practices has distinct characteristics, but they also work synergistically together.
  - Often lessons will include more than 1 practice, but they probably will not include all 8 practices.
- Supporting students in science practices is challenging and requires multiple opportunities and different types of support for students.
- Current curriculum and lessons can be adapted to include a greater focus on the practices, but out goal for meeting is to try and develop a better understanding of "how".

Next Time: Plan to Try out a Practice before April 1

- Before our next meeting on April 1, we would like you to engage your students in one of the eight science practices.
- For the meeting on April 1, please bring:
  - Planning sheet that identifies the target practice and a "lessons learned" (e.g. lesson challenge, student challenge, strategy).
  - Lesson artifacts – Bring in something to share to illustrate the "lesson learned" such as a powerpoint to illustrate a strategy or student writing to illustrate a challenge.
  - *If you were comfortable, we would like to collect the planning sheets and artifacts to help us synthesize the lessons learned.*

Contact Information

- Kate's e-mail – kmcneill@bc.edu
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http://www.katherinelmcneill.com

- Workshops
  - Has the powerpoint
- Teaching Resources
  - Links to other webpages (e.g. argument assessments, lessons, etc.)