Instructional Leadership for Science Practices:

Supporting Teachers in Transitioning to the New Science Standards

Katherine L. McNeill, Boston College

Outline

- Science as a set of practices
  - Rationale and challenges with practices
  - Video from 3rd Grade classroom
- Science Practices – 3 Groups
  - Grouping the practices
  - Frequency of the 3 groups in k-8 science
- Science Practices Continuum
  - Moving along a continuum
- Example Practice: Engaging in Argument from Evidence
  - Define argument – 2 key levers
  - Video of argument in a 7th grade classroom
  - Transcript of argument in a 6th grade classroom
  - Instructional Strategies linked to the key levers

Powerpoint – www.katherinelmcneill.com (Presentations)

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Science Practices: A shift in science education

- Historically, science education has overemphasized students learning a myriad of facts rather than understanding how ideas are developed and transform over time (Roth & Garnier, 2006).
- “Science is not just a body of knowledge that reflects current understanding of the world; it is also a set of practices used to establish, extend, and refine that knowledge. Both elements – knowledge and practice – are essential” (NRC, 2012, p. 26).

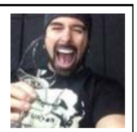
Science Practices: What are they?

- "Engaging in the practices of science helps students understand how scientific knowledge develops…The actual doing of science or engineering can also pique students' curiosity, capture their interest, and motivate their continued study" (NRC, 2012, p. 42)
- Eight NGSS 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

Science Practices: 3 Potential Challenges

- Actively engage students
  - Students need to actively engage in the practices, not just observe their teachers engage in the practices (NRC, 2012).
- Integrate practice and content
  - The practices and disciplinary core ideas need to be integrated coherently in curriculum, instruction and assessment (NRC, 2012).
- Not everything is a science practice
  - The term "inquiry" has been used in many different ways (NRC, 2012), the same concern potentially exists with science practices (McNeill, et al., 2016).

3rd Grade Sound Unit



- We are going to watch a 7 minute video from a 3rd grade unit about sound
  - http://ambitiousscienceteaching.org
  - Initial Question - Why can a singer shatter a glass with his voice?
- Discussion Questions:
  - What did you notice about what the students said, did, or wrote?
  - What science practices did you observe in this 3rd grade classroom?
  - How is this similar and different from science instruction in your school?

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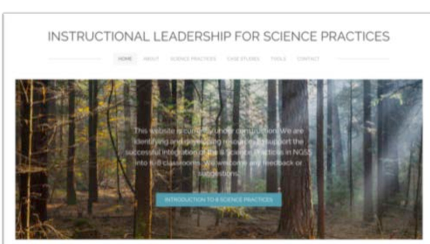
Science Practices Continuum

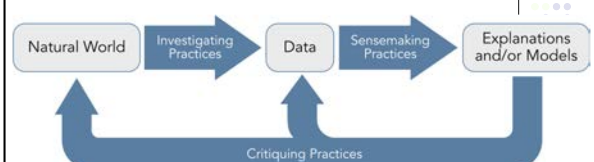
(McNeill, Katsh-Singer & Pelletier, 2015)

- Instructional Leadership for Science Practices
  - www.sciencepracticesleadership.com



Grouping the Practices

(McNeill et al., 2015)



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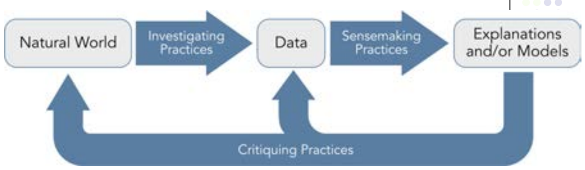
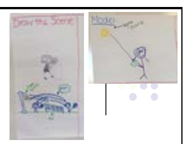


Investigating Practices	Sensemaking practices	Critiquing Practices
1. Asking questions 3. Planning and carrying out investigations 5. Using mathematical and computational thinking	2. Developing and using models 4. Analyzing and interpreting data 6. Constructing explanations	7. Engaging in argument from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

Investigating Practices

- Investigating practices focus on asking questions and investigating the natural world.
- The products of these investigations are <u>data.</u>
- This includes 3 science practices
  - Asking questions
  - Planning and carrying out investigations
  - Using mathematical and computational thinking

Sensemaking Practices



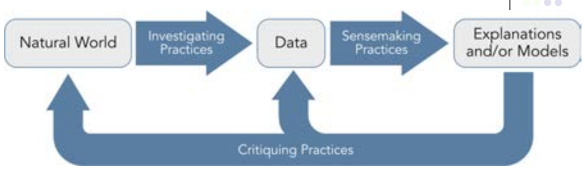
- The Sensemaking Practices focus on making sense of that data by looking for patterns and relations to develop explanations and models.
- This includes 3 science practices
  - Analyzing and interpreting data
  - Constructing explanations
  - Developing and using models

Critiquing Practices

- The Critiquing Practices emphasize that students need to compare, contrast and evaluate competing explanations and models as they make sense of the world around them.
- Critique is a hallmark of the practices of scientists, but is frequently absent from k-12 science instruction (Osborne, 2012).
- This includes 2 science practices:
  - Engaging in argument from evidence
  - Obtaining, evaluating and communicating information.

Grouping the Practices

(McNeill et al., 2015)



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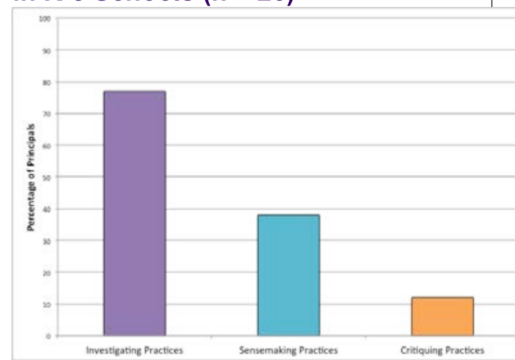
Current Science Instruction in K-8 Schools (n = 26)



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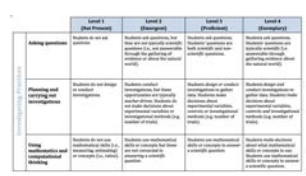

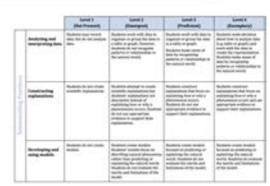

Science Practices Continuum
(McNeill et al., 2015)

Sensemaking Practices		Level 1 (Not Present)	Level 2 (Emergent)	Level 3 (Proficient)	Level 4 (Exemplary)
	Analyzing and interpreting data	Students may record data, but do not analyze data.	Students work with data to organize or group the data in a table or graph. However, students *do not recognize patterns or relationships* in the natural world.	Students work with data to organize or group the data in a table or graph. Students make sense of data by *recognizing patterns or relationships* in the natural world.	Students *make decisions* about how to analyze data (e.g. table or graph) and work with the data to create the representation. Students make sense of data by *recognizing patterns or relationships* in the natural world.
	Constructing explanations	Students do not create scientific explanations.	Students attempt to create scientific explanations but students' explanations are *descriptive* instead of explaining how or why a phenomenon occurs. Students do *not* use appropriate evidence to support their explanations.	Students construct explanations that focus on explaining *how or why a phenomenon* occurs. Students do *not* use appropriate evidence to support their explanations.	Students construct explanations that focus on explaining *how or why a phenomenon occurs* and *use appropriate evidence* to support their explanations.
	Developing and using models	Students do not create models.	Students create models. Students' models focus on *describing natural phenomena* rather than predicting or explaining the natural world. Students *do not evaluate* the merits and limitations of the model.	Students create models focused on *predicting or explaining* the natural world. Students *do not evaluate* the merits and limitations of the model.	Students create models focused on *predicting or explaining* the natural world. Students *do evaluate* the merits and limitations of the model.

2 or 3 Key Levers for each Science Practice

Science Practices Continuum
(McNeill et al., 2015)

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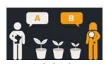
Engaging in Argument from Evidence

	Level 1 (Not Present)	Level 2 (Emergent)	Level 3 (Proficient)	Level 4 (Exemplary)
Engaging in argument from evidence	Students do not engage in argumentation.	Students engage in argumentation where they support their *claims with evidence or reasoning*, but the discourse is primarily *teacher-driven.*	Students to engage in *student-driven argumentation.* The student discourse includes *evidence and reasoning* to support their claim. Students also agree and disagree, but rarely engage in critique.	Students engage in *student-driven argumentation.* The student discourse includes evidence, reasoning that links the evidence to their claim and *critique* of competing arguments during which students build on and question each other's ideas.

Argument from Evidence

Structure

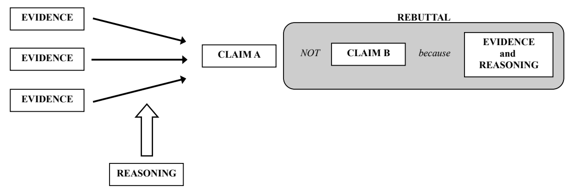
- Claim – Provides a conclusion or solution
- Evidence – Scientific data such as measurements or observations
- Reasoning – Explains why the evidence supports the claim



Process

- Multiple Claims – Students compare and critique multiple claims
- Student Interactions through critique – Students pose and respond to questions to challenge ideas and resolve conclusions

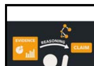
CER Framework (McNeill & Krajcik, 2012)



Physics Example

Does a lever make work easier?

Levers sometimes make work easier. (Claim) When we picked up the load without the lever, it was 2.2 N. When the load was 5.0 cm from the fulcrum and the effort was 10 cm from the fulcrum, it was 0.8 N. When the load was 20 cm from the fulcrum and the effort was 10 cm from the fulcrum, it was 4.3 N. When the load was 10 cm from the fulcrum and the effort was 5.0 cm, it was 5.3 N. When the load was 10 cm from the fulcrum and the effort was 20 cm, it was 1.3 N (Evidence) Doing work is the ability to move an object. If it takes less force, the work is easier. A lever can make work easier depending on the position of the fulcrum, effort and load. When the fulcrum is close to the load and far from the effort, the work is easier. (Reasoning)



Environmental Science Example

Mr. Garcia: Do you think the climate is changing? Make sure you support your idea with evidence and reasoning.

Olivia: I think the climate is changing (Claim) because this fall has been really warm (Evidence).

Mariela: Does being warm just one fall count as evidence for climate change?

Nate: No, climate is long term changes. It is just weather if it is one day or a month or a season (Reasoning). So I agree with Olivia that the climate is changing (Claim). But I think it is changing because the air temperature has slowly gotten warmer over a long time. The average temperature has increased like 2 degrees in the last 100 years (Evidence).

Engaging in Argument from Evidence

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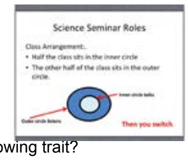
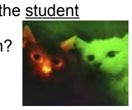
7th Grade Example



7th Grade Lesson Focus:
- Context: Heredity Unit
- Question: What kind of allele causes the glowing trait?
- 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 the cats. Data about crosses from jelly fish.
- Activity: Science Seminar

Questions to Consider for CER structure and process:
- What are the strengths and challenges in terms of the student talk?
- How did the teacher support the student discussion?
  - What are some aspects that he did well?
  - What are some areas in which he could improve?



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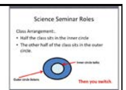
- What level would you place the students' argumentation? Why?

6th Grade Example



- A Science Seminar exploring the question - *How will the Indian plate be different in 50 million years?*
- Below is an excerpt from the beginning of the conversation. Pablo volunteered to go first and he initially read his argument to Ms. Richardson and this is how she responded:
- *Ms. Richardson: Pablo, I am going to ask that you say that one more time and a little bit slower and a little bit clearer. And make sure you address the people in the inside circle and not me. So pretend I am not here. Ok. Go ahead.*
- *Pablo: My claim is that the Indian plate will get smaller in 50 million years. My evidence is that on the collision zone – the Indian plate is located at a collision zone. And my reasoning is that at a collision zone, the plate folds and crumbles.*

A number of students raise their hands.

- *Ms. Richardson: Ian.*

6th Grade Example

- *Ian: I disagree with Pablo. Because on the map it is surrounded by spreading zones. And my reasoning is that spreading zones will have it - that it will make new crust.*

A number of students raise their hands.

- *Ms. Richardson: Jose.*
- *Jose: My claim is that the Indian plate will get bigger and my evidence is that there are spreading zones around the boundaries of the Asian plates - at spreading zones plates move apart from each other.*
- *Ms. Richardson: So, Jose are you saying you agree with Pablo or you agree with Ian?*
- *Jose: I agree with Pablo because he said it - oh, I agree with Ian that the Indian plate will get bigger.*

Engaging in Argument from Evidence

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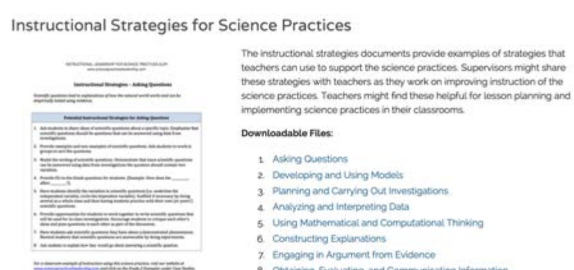
Instructional Strategies for Science Practices

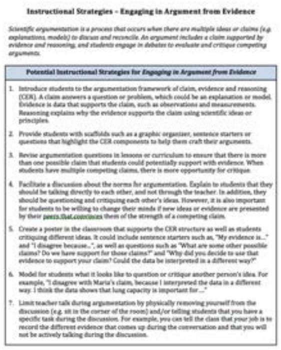

Instructional Strategies for Science Practices

The instructional strategies documents provide examples of strategies that teachers can use to support the science practices. Supervisors might share these strategies with teachers as they work on improving instruction of the science practices. Teachers might find these helpful for lesson planning and implementing science practices in their classrooms.

Downloadable Files:

1. Asking Questions
2. Developing and Using Models
3. Planning and Carrying Out Investigations
4. Analyzing and Interpreting Data
5. Using Mathematical and Computational Thinking
6. Constructing Explanations
7. Engaging in Argument from Evidence
8. Obtaining, Evaluating, and Communicating Information

7 Instructional Strategies for Argumentation



Instructional Strategies – 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, and students engage in debates to evaluate and critique competing arguments.

Potential Instructional Strategies for *Engaging in Argument from Evidence*

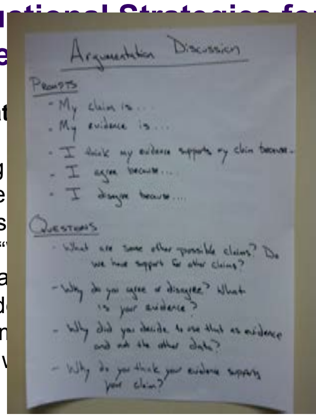
1. Introduce students to the argumentation framework of claim, evidence and reasoning (CER). A claim answers a question or problem, which could be an explanation or model. Evidence is data that supports the claim, such as observations and measurements. Reasoning explains why the evidence supports the claim using scientific ideas or principles.
2. Provide students with scaffolds such as a graphic organizer, sentence starters or questions that highlight the CER components to help them craft their arguments.
3. Revise argumentation questions in lessons or curriculum to ensure that there is more than one possible claim that students could potentially support with evidence. When students have multiple competing claims, there is more opportunity for critique.
4. Facilitate a discussion about the norms for argumentation. Explain to students that they should be talking directly to each other, and not through the teacher. In addition, they should be questioning and critiquing each other's ideas. However, it is also important for students to be willing to change their minds if new ideas or evidence are presented by their peers that convinces them of the strength of a competing claim.
5. Create a poster in the classroom that supports the CER structure as well as students critiquing different ideas. It could include sentence starters such as, "My evidence is…" and "I disagree because…", as well as questions such as "What are some other possible claims? Do we have support for those claims?" and "Why did you decide to use that evidence to support your claim? Could the data be interpreted in a different way?"
6. Model for students what it looks like to question or critique another person's idea. For example, "I disagree with Maria's claim, because I interpreted the data in a different way. I think the data shows that lung capacity is important for …"
7. Limit teacher talk during argumentation by physically removing yourself from the discussion (e.g. sit in the corner of the room) and/or telling students that you have a specific task during the discussion. For example, you can tell the class that your job is to record the different evidence that comes up during the conversation and that you will not be actively talking during the discussion.

7 Instructional Strategies for Argumentation

- #5. **Create a poster** in the classroom that supports the CER structure as well as students critiquing different ideas. It could include sentence starters such as, "My evidence is…" and "I disagree because...", as well as questions such as "What are some other possible claims? Do we have support for those claims?" and "Why did you decide to use that evidence to support your claim? Could the data be interpreted in a different way?"

7 Instru… Argume…

- #5. **Creat…** …at supports … …tudents critiquing … sentence … …e is…" and "I dis… …uestions such as "… …claims? Do we ha… …and "Why did you d… …upport your clai… …d in a different v…



7 Instructional Strategies for Argumentation

- #4 **Facilitate a discussion about the norms for argumentation.** Explain to students that they should be talking directly to each other, and not through the teacher. In addition, they should be questioning and critiquing each other's ideas. However, it is also important for students to be willing to change their minds if new ideas or evidence are presented by their peers that convinces them of the strength of a competing claim.

- #7 **Limit teacher talk** during argumentation by physically removing yourself from the discussion (e.g. sit in the corner of the room) and/ or telling students that you have a specific task during the discussion. For example, you can tell the class that your job is to record the different evidence that comes up during the conversation and that you will not be actively talking during the discussion.

Stepping Back During Science Seminars

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

The Learning Design Group

http://www.argumentationtoolkit.org/argument-elements.html

Conclusions

- The focus on science practices is an exciting but challenging time.
- Students need support to actively engage in these practices while they are simultaneously applying and developing stronger understandings of disciplinary core ideas.
- Grouping the 8 science practices into Investigating, Sensemaking and Critiquing can be an entry point for analyzing current science lessons.
- The Science Practices Continuum offers key levers for each practice that are linked to Instructional Strategies to move students towards greater proficiency.

Contact Information

- Kate McNeill
  - e-mail – kmcneill@bc.edu
  - website – www.katherinemcneill.com
    - *Links to Instructional Leadership for Science Practices (ILSP)*
    - *Argumentation Toolkit*
  - Opportunity - NSF funded PD for k-8 principals on practices
    - Saturday, Dec. 3, Wednesday, Jan. 25 and Wednesday, March 22

- Thanks to the National Science Foundation
  - *Constructing and Critiquing Arguments in Middle School Science Classrooms,* DRL-1119584.
  - *Instructional Leadership for Scientific Practices*, DRL-1415541.