THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

Argumentation & Scientific Discourse

Santa Barbara

5th & 6th grade

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Lawrence Hall of Science

Goals for the Day

- focus on development of argumentation skills and its role in meaning-making for middle schools students
- connect the practice of argumentation in science to critical thinking, collaboration and communication skills
- explore strategies for supporting student engagement in argumentation

What is argumentation?

Argumentation is the process of constructing and critiquing arguments, which consist of claims, evidence, and reasoning.

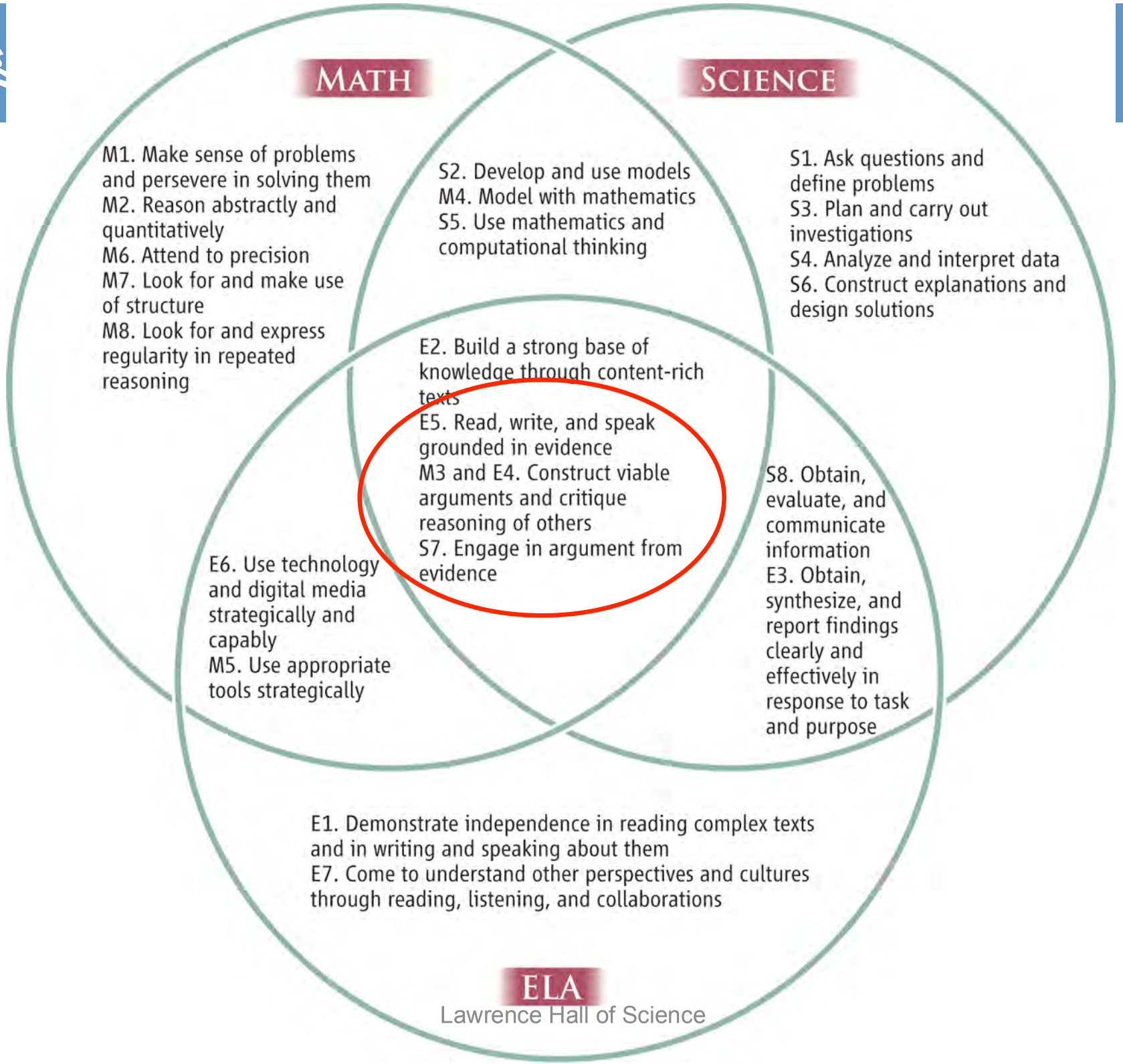
What is argumentation in the classroom?

Argumentation in science education is **a** process of proposing, supporting, evaluating, and refining ideas in an effort to…

develop a better conceptual understanding and/or better engineering design.

Importance of Argumentation for Students

- Supports students' understanding of disciplinary core ideas of science and crosscutting concepts
- Helps students build an understanding of the nature of scientific knowledge
- Promotes literacy development and writing skills ala CCSS
- Allows students to critically examine claims made in the media



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Guiding Questions for educators

- How can we facilitate the learning experiences to help our students come to a deeper, more accurate understanding of science?
- How can models, claims and evidence be used to help our students construct explanations?
- How can we keep track of our students' growing understandings along the way?

Evidence For and Against

- Heavy things sink because they weigh more than things that float.
- The substance the object is made of determines whether it floats or sinks.
- The temperature of an object or substance determines whether it floats or sinks.
- The density of an object or substance determines whether it floats or sinks.

Debrief For/Against Activity

How does the activity help students to build argumentation skills or to clarify the skills needed for argumentation?

The Mystery of the Floating Balloons

What makes things Float or Sink?

Challenge to design your own Investigation: Make balloons that float, sink, suspend in water

- Fill balloon with a test Substance
- Make a Prediction
- Record the Result

Key Concept

Scientists need to be ready to change their ideas, predictions (claims), and explanations based on new evidence.

Scientific Language

I think...because of the evidence....

I agree because....

I disagree because....

You convinced me because....

Could you explain more about why you think...?

Models used in Ocean Science activities

- inflatable Earth globes
- maps
- table-top containers with different temperatures and salinities of water
- large tank with different temperatures of water
- cup with marbles & salt

Molecular Model Cards

- Look through the cards representing molecules.
- Discuss with a partner how the cards could be used to explain the differences between the substances inside the balloons.
- Use the cards to discuss your explanation for what caused the balloons to float or sink.

Scientific Statements

- All molecules of a particular substance are the same shape and size.
- Under normal conditions, molecules can't change shape or size.

Density

- For any type of substance, such as water, it will be more dense if the molecules are closer together. It will be less dense if the molecules are farther apart.

Using Modeling to explain a phenomenon

- The balloon containing hot water was floating at the top of the tank.
- After about 10 minutes this balloon sank to the middle of the tank.
- What happened???

MORE Scientific Statements About Molecules

- Molecules are always moving.
- Increasing the temperature of a substance (adding heat energy) increases the movement of its molecules.
- When molecules collide they can transfer energy.

Creating, Sharing & Evaluating Models

- Create a model with a partner - 10 minutes
- Make sure that your model:
  - explains why the balloon eventually sank
  - fits what we know about molecules - the scientific statements

Share your model with another pair and provide feedback on whether their model meets the criteria

Thinking about sense-making

- What role did discussion and argumentation and modeling serve in sense-making?
- Which cross cutting concepts were applicable to understanding the science?
- Which scientific practices were used in order to complete the task?

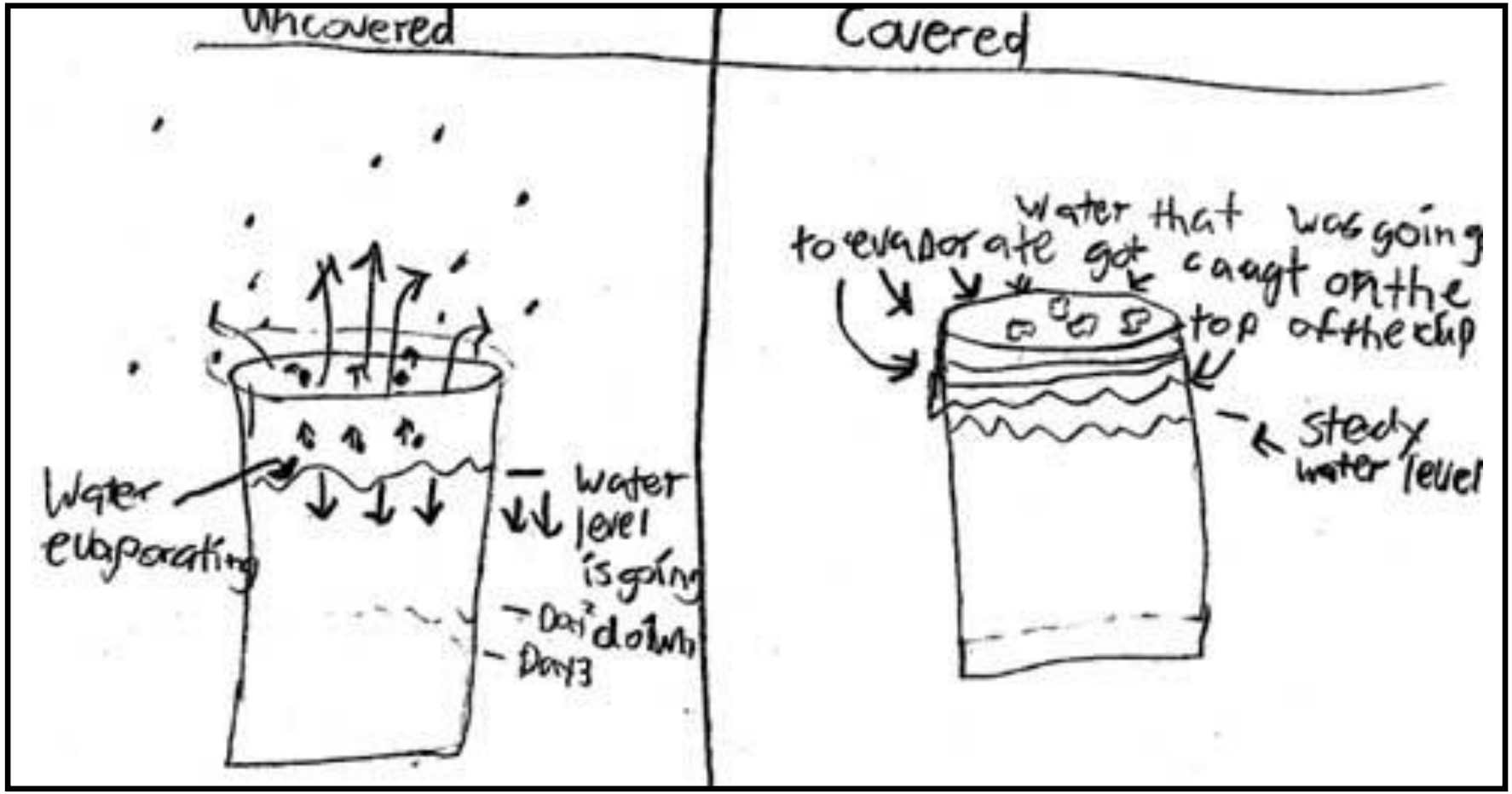
Primary purpose for Using Scientific Models

In science, a model is a tool used to make sense of the world.

Models = explanations

Models are also used in engineering for analyzing, testing, and designing.

An example of a student's conceptual model for evaporation



What is Scientific *Modeling*?

- ***Developing*** a model that embodies aspects of an explanation and the evidence
- ***Evaluating*** that model against empirical evidence and the explanation
- ***Using*** the model to illustrate, predict and explain
- ***Revising*** the model based on more evidence

Key Elements of Modeling

- Model explains the phenomenon and helps us make predictions.
- Involves cycles of model development, evaluation, and revision within a social setting.
- Model must be consistent with (and evaluated against) observational data and established scientific ideas.

According to NGSS argumentation is…

a process based on evidence and reasoning that leads to explanations acceptable by the scientific community and design solutions acceptable by the engineering community.

-NGSS Appendix F

Some important argumentation terms

Explanation: answers why or how something happens

Claim: a statement proposed for acceptance; an explanation that is open to discussion and substantiation

Evidence: data or facts supporting a claim. Evidence is not simply found. For a fact or data to become evidence, it must be linked through an argument to an interpretation or explanation. The evidence must be acceptable by the standards of the discipline.

Reasoning: discussion of the relevancy of data/evidence to a claim; connects a claim with the evidence; can address the strength of the claim, how sure you are about it

Counterclaim: can be a rebuttal to the claim, reservations about the claim, or can describe exceptions to the claim and/or situations where it doesn't apply

Argument: the product of argumentation. An argument is in response to a question, (stated or unstated) where the answer is necessarily uncertain among the people considering it.

"Science is a set of methods designed to describe and interpret observed or inferred phenomena, past or present, and aimed at building a testable body of knowledge open to rejection or confirmation."

Michael Shermer
Director of Skeptics Society

Scientific Argumentation is not this…

But it is…

a process of proposing, supporting, evaluating, and refining ideas in an effort to develop a better understanding

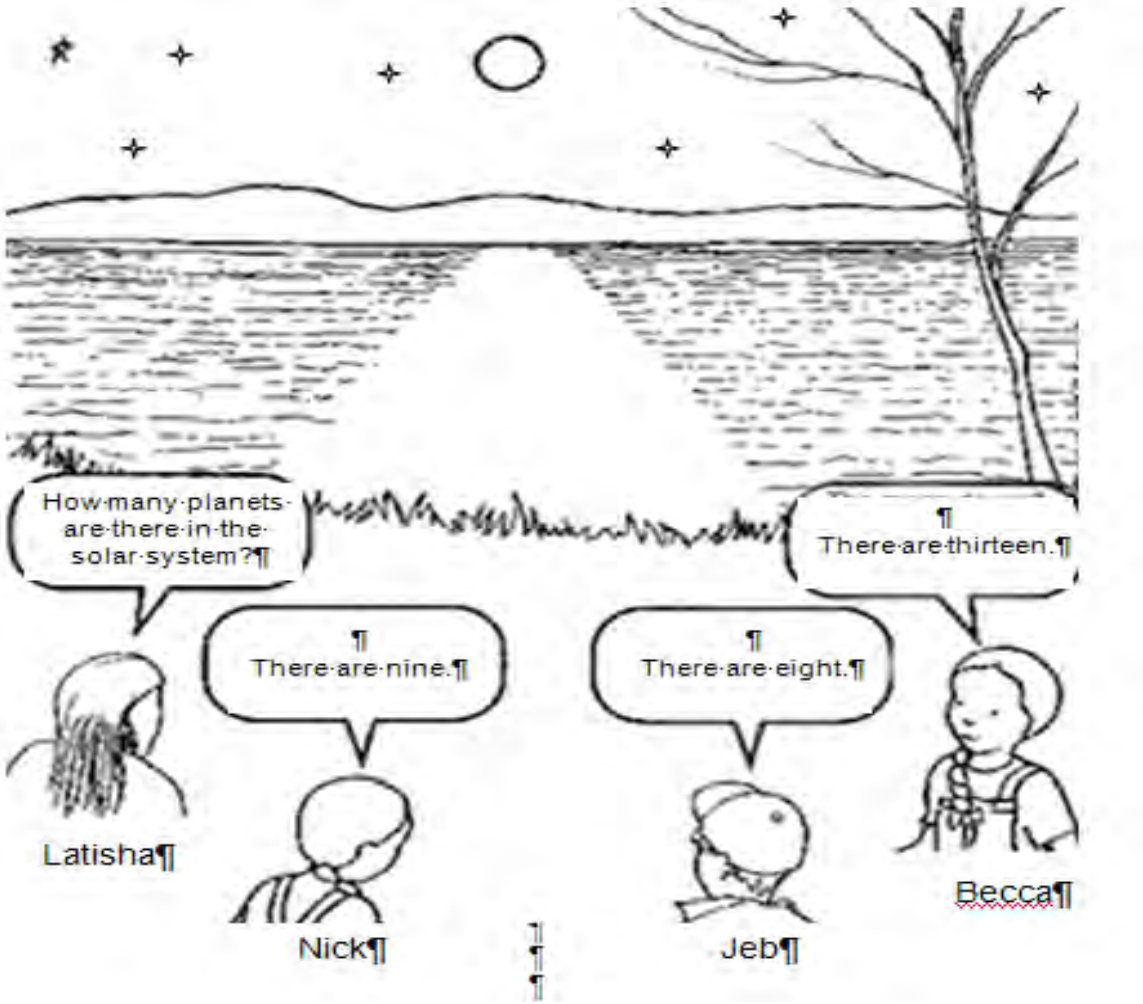
Engaging in Argument from Evidence

In science, reasoning and argument, are essential for identifying the strengths and weaknesses of a line of reasoning and **for finding the best explanation** for a natural phenomenon.

Scientists must defend their explanations, formulate evidence based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers in searching for the best explanation for the phenomena being investigated.

Scientists engage in argument to:

- Defend claims using evidence and reasoning:
  - Interpretation of data
  - Experimental designs
  - Method of data analysis
  - The appropriateness of a question
- Defend models
  - evaluate and compare different models
- Critique the claims of other scientists
  - Look for sufficient and appropriate evidence



Who is right?
How do you know?

In other words…

"Secure knowledge and understanding is as much a product of knowing why some ideas are **erroneous** as why other ideas are correct."

–Osborne, Erduran, and Simon (2004)

High Quality Evidence

Evidence is information about the natural world th·at is used to support a claim. In a scientific argument, evidence often consists of data, which can be measurements and observations.

- Data becomes evidence when it is used to support a claim.
- The quality of the evidence supporting a claim can be more important than the quantity.
- Quality of evidence depends on a variety of factors including reliability of the source and reproducibility.

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Criteria for Evaluating the **STRENGTH** of Evidence

- ❑ Quantity of evidence
- ❑ Size of assumption
- ❑ Quality of source

Useful Criteria: Quantity of Evidence

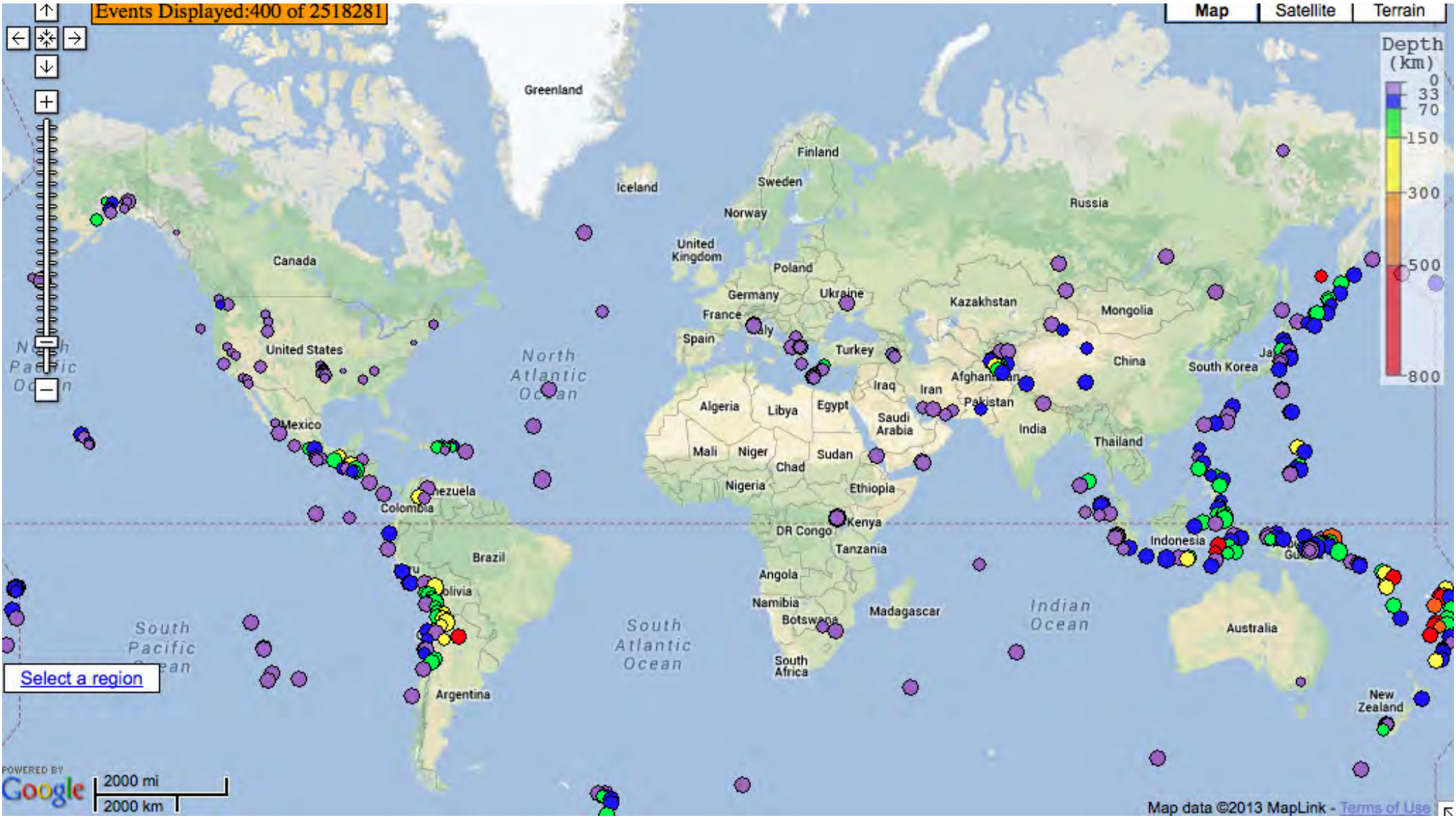
How much evidence has been collected that supports the explanation?

Where do earthquakes usually occur?

100 data points

Where do earthquakes usually occur?

400 data points



Where do earthquakes usually occur?

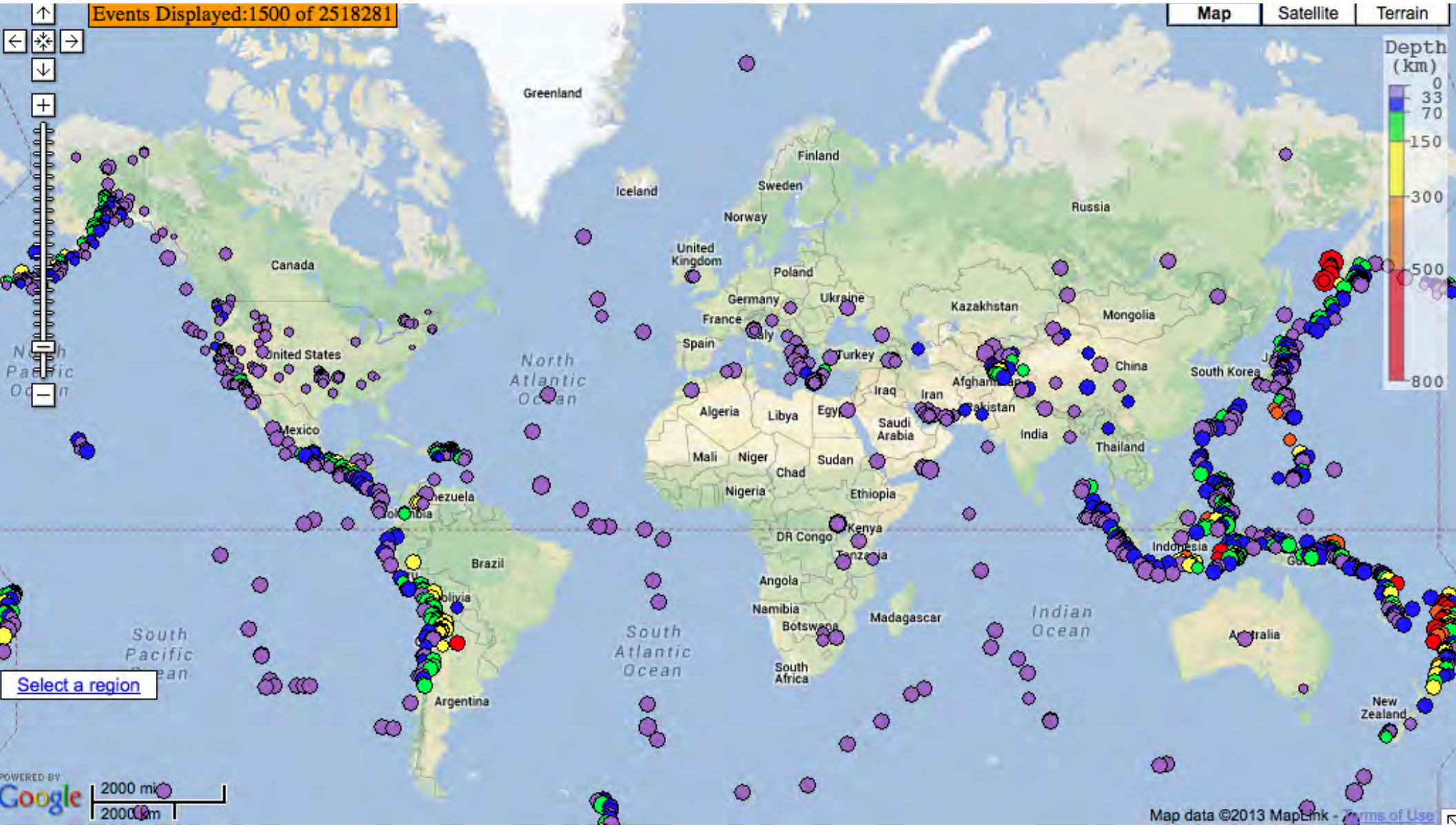
800 data points

Where do earthquakes usually occur?

1,000 data points

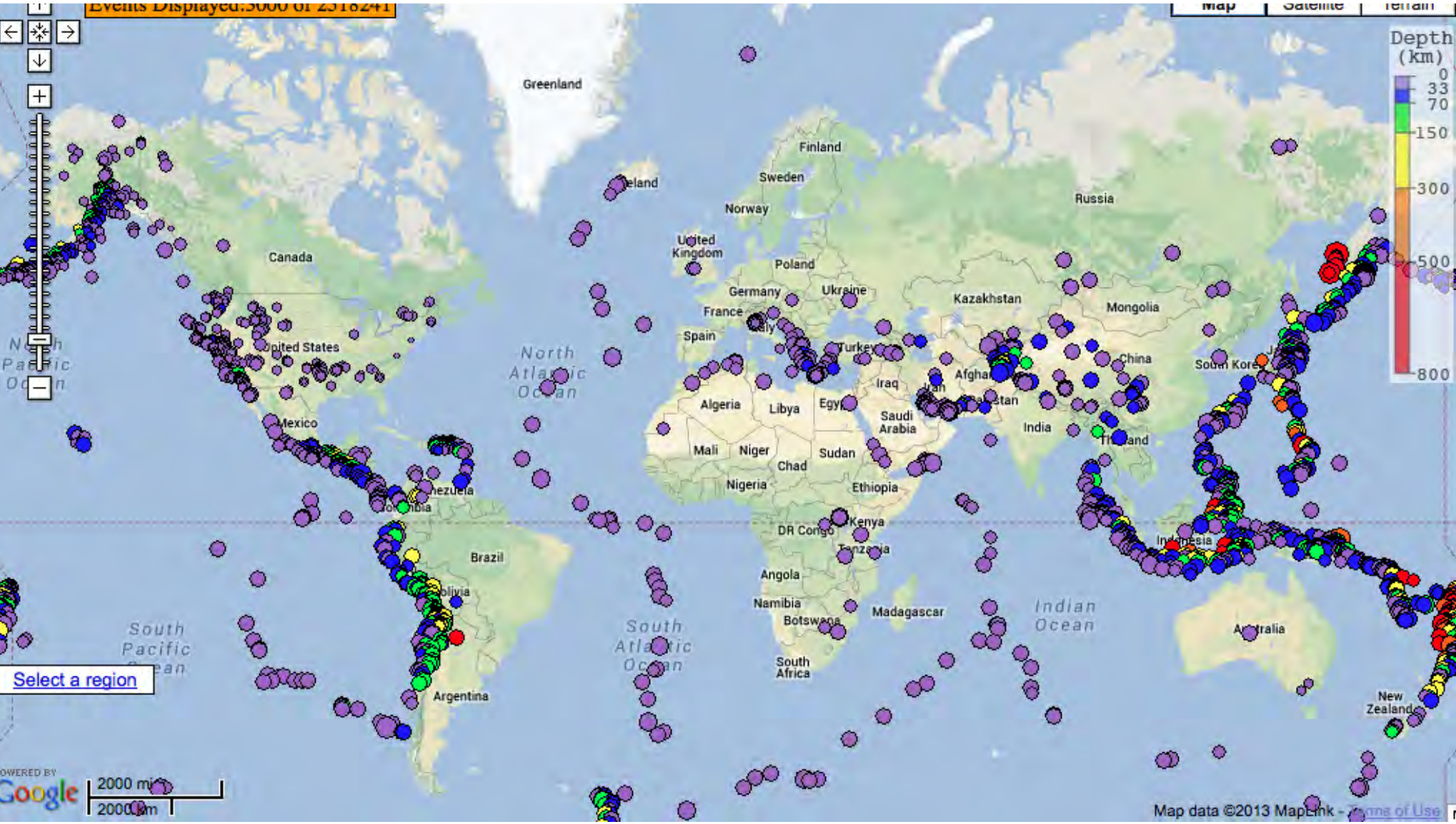
Where do earthquakes usually occur?

1,500 data points



Where do earthquakes usually occur?

3,000 data points



Useful Criteria: Size of Assumption

How much of a conceptual leap does it take to connect the evidence to the possible explanation?

??

?

Sort the cards in order of size of the assumption needed to support this explanation:

Cheetahs are predators of wildebeest.

Useful Criteria: Quality of Source

Where did the evidence come from and how reliable is it?

Sort the cards in order of highest to lowest quality of source.

How is argumentation in school different from what scientists do?

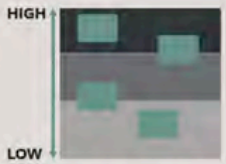
How do students learn the language and processes of argumentation?

A major aim of the science curriculum is for students to acquire an understanding of the scientific view of the world and to use scientific reasoning when appropriate.

Ironically, this aim is undermined when students commit to memory a great deal of scientific knowledge but grasp little of the grounding for that knowledge.

-Norris, Phillips, and Osborne, 2007

Argumentation Activities



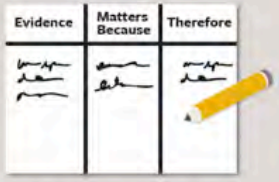
In the **evidence gradient tool** students rank evidence cards according to particular criterion for evidence quality. Subsequently, students rank evidence cards by how well they support a given claim.

When **gathering evidence** students can engage with hands-on, simulations, text or diagrams to identify and record evidence in relation to a claim.

In the first use of the **anticipation guide** students respond to several claims containing common misconceptions. Later, students revise their responses and eventually rewrite the claims.

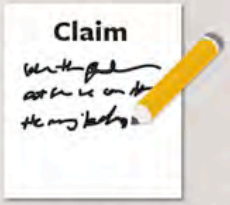
In an **evidence card sort** students sort evidence cards according to which or several competing claims the evidence best supports.

In **oral argumentation** students engage in interactive discourse where they both build on each other's ideas and critique peer's arguments.



In the **reasoning tool** students fill in three columns for evidence, reasoning and claim. The central reasoning column is filled in last as the link between evidence and claim.

In a **science seminar** students participate in a whole class, student-led discussion, with a day before for exploring evidence and claims, and a day after for argument writing.



In **argument writing** students provide a claim that is supported by high quality evidence with clear reasoning connecting the claim and evidence.

THE ARGUMENTATION TOOLKIT

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Scientific Argument Diagram

Scientific Argument

Question: about the natural world

Claim: a proposed answer to a question about the natural world

Reasoning

Reasoning

Evidence: Information about the natural world that is used to support or refute a claim

Reasoning

Evidence: Information about the natural world that is used to support or refute a claim

Reasoning Tool

Evidence	This evidence matters because . . .	Therefore, . . .

Argument About Vegetables

Claim: Vegetables are good for you.

Evidence used in argument: Vegetables contain fiber and vitamins, such as Vitamin C.

Reasoning Tool: Vegetables (with reasoning)

Evidence	This evidence matters because . . .	Therefore, . . .
Vegetables contain Vitamin C.	**Eating vegetables and fruits that contain a lot of Vitamin C can help heal wounds and protect against colds and allergies.**	Vegetables are good for you. 
Vegetables contain fiber.	**Eating vegetables that contain fiber can reduce the risk of heart disease, obesity, and type 2 diabetes.**	

Comparing Arguments About Vegetables

Argument #1

Vegetables are good for you. They contain fiber and vitamins, such as Vitamin C. You should eat vegetables every day.

Argument #2

Vegetables are good for you. They contain fiber. Scientists have found that fiber can reduce the risk of heart disease, obesity, and type 2 diabetes.

Vegetables also contain important vitamins, such as vitamin C. Vitamin C has been shown to heal wounds and may even help protect us against colds and allergies. Since they have so many health benefits, you should eat vegetables every day.

Questions to ask when evaluating arguments in science

- Is the explanation ***sufficient*** and ***coherent***?
- Is there ***enough evidence*** to support their ideas?
- Is the evidence of ***high quality***?
- Is there any ***counterevidence*** that does not support the explanation?
- How well does the explanation ***fit with other theories and laws*** that are used in science to explain or describe how the world works?
- Is the reasoning ***sufficient*** (it explains why the evidence was used and why it supports the explanation) and ***appropriate*** (rational and sound)?

What does it take to get argumentation to happen in a classroom?

1. Establish norms to support a culture of academic talk
2. Focus on reaching the best explanation or solution – emphasize why argumentation is important
3. Pose opposing, evidence-based, explanations that can be argued
4. Provide practice with opportunities to explain, critique and justify science ideas – model and employ scaffolds
5. Give students a chance to address their naïve conceptions
6. Engage students in generating and interpreting data

Argumentation Prompts

- How do you know that?
- What evidence supports your idea/explanation?
- What have you observed that tells you that?
- What's the quality of the evidence?
- Does the explanation fit with what we know about how the world works?
- Do you agree with this explanation? Why or why not?
- What are some other possible explanations?
- Which idea is best supported by the evidence we have?

Greater sophistication in argumentation

Grades K - 2	Grades 3 - 5	Middle School	High School
Make a claim and use evidence	Construct and support scientific arguments drawing on evidence, data, or a model. Consider other ideas.	Construct and present oral and written arguments supported by empirical evidence and reasoning to support or refute an explanation for a phenomenon.	Construct a counter-argument that is based in data and evidence that challenges another proposed argument.

To engage students in the NGSS Scientific practices we must:

- provide opportunities for conversations about science ideas
- emphasize connections between ideas and evidence
- use argumentation to weigh evidence learn science ideas

Teacher Challenges

What do you think will be most challenging about incorporating argumentation into your teaching?

- Having students use evidence
- Providing alternative explanations
- Students being respectful of other students' ideas
- Supporting students in writing arguments

Student challenges

- Using evidence to support their ideas
  - Can rely on their own opinions and/or have difficulty using sufficient evidence
- Explaining why their evidence supports their ideas
  - Can have difficulty articulating this link and/or using scientific principles
- Considering alternative claims
  - Can focus on one idea
- Revising arguments based on new evidence
- Taking into consideration the viewpoints of others

Conclusions

- Arguments build and refute claims using evidence and reasoning
  - Explanations, questions, data analysis, and design
- Explanations and designs are the final artifacts
- Need to support students if they are going to engage in argumentation
  - E.g. “a structure”, “models”, “critiques”, “norms”
- Important to build understanding of argumentation overtime
- All learners can engage in the practice!

Some resources to support teachers…

- Talk Science from TERC:
  http://inquiryproject.terc.edu/prof_dev/
- Teaching Argumentation in the Classroom:
  http://www.pstt.org.uk/ext/cpd/argumentation/index.php
- The Argumentation Toolkit from Lawrence Hall of Science:
  http://www.argumentationtoolkit.org/