

Scientific Argument Tutorial



Making a Strong Argument

Part 1 of 5 – What is Argument in Science?

Everyday, people attempt to convince others to agree with their ideas or opinions. How can you decide which ideas are strong and which are weak? How can you evaluate the ideas or opinions of others so as to make a sound decision? One way to is to evaluate whether an opinion or idea is supported by strong evidence and reasoning.

When an opinion is science-based and supported by both scientific evidence and reasoning (known science concepts), it is called a **scientific argument**.



Scientific Argument – a statement that is supported by multiple pieces of measured or observed evidence and links it all together with science facts and

Explicitly teach students WHY learning to make and evaluate an argument is important:

- *Scientific Arguments are found everywhere and heard every day-part of our society (e.g. media, advertising, medicine, etc.)*
- *Students need to learn to recognize them and evaluate them to decide if they agree, want to buy a product, follow scientific breakthroughs, or even seek out certain medicine*
- *Ultimately students need to learn to make their own arguments to persuade others of their ideas*
- *Give a real world example of scientific arguments (“Who is the best___ (basketball player, X or Y).”)*

Let’s watch and compare two individuals that are each making an argument to answer the question: Should runners run barefoot or with shoes? As you watch the videos think about what makes for a strong, persuasive argument. As a class you will discuss the answers to the following questions:

- What are the ideas or opinions expressed by each speaker?
- What was different in *how* each speaker made their case?
- Who has the strongest (more believable) argument and why?
- The speaker who is less believable, what would make his argument stronger?
What is missing?

Scientific Argument Tutorial



Watch Tutorial
Video 1



Watch Tutorial
Video 2

CLASS

Watch the videos and think about the questions above. Take notes on the videos in your student pages on the **A-Scientific Argument Notes** sheet. Afterwards you will discuss your answers as a class.

Name	Teacher	Period
		Date

Scientific Argument Notes
Part 1 of 5 *What is Argument in Science?*

Define SCIENTIFIC ARGUMENTATION:

Notes from Video #1	Notes from Video #2
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What are the three components of a scientific argument?

- 1)
- 2)
- 3)

Ideas or opinions are different from arguments. **Opinions are not arguments because they lack three critical components: claim, evidence, and reasoning.** Similarly, a scientific argument has a science-based claim, is supported by evidence, and understood through known scientific facts (reasoning).

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A scientific argument...

- ... IS NOT fighting
- ... IS NOT me against you
- ... IS NOT only based on opinions and beliefs

A scientific argument...

- ... IS presenting an idea and supporting it with evidence & facts
- ... IS found everywhere in daily life
- ... IS a way to persuade others truthfully

Emphasize Scientific Argumentation as a type of discourse where EVERYONE's ideas are heard and respected. Setting and enforcing good classroom discussion norms or classroom rules will greatly enhance instruction of scientific argumentation. If you have a set of class rules posted in your room you might want to refer to it at this time. If you don't or they do not emphasize listening and/or how to respond to classmates in a discussion you should set and post rules now to refer to them in future.

The Building Blocks of Scientific Argument

Scientific Argument: A set of persuading statements answering a scientific question that includes a claim supported by multiple pieces of evidence and a reasoning statement explaining what science concept links it all together.

Three Components of a Scientific Argument:

Claim: a statement about a phenomena or event (written as a full sentence).

Evidence: a trend or pattern from measurements and observations, collected during an investigation, that supports a claim.

Scientific Reasoning: known science fact or knowledge that explains the connection between evidence and claim.

- *Write these definitions on a post-it or poster to hang in class to refer back to throughout the year (there will be four posters all together).*

As you watched the argument videos you might not have noticed when opinions were being used instead of science facts. For the next few class periods you are going to engage in a tutorial *to learn how ideas can be presented and supported with facts and reasoning*. You are going to learn about strong scientific arguments that are convincing to others (i.e. your classmates, teacher, and/or a city council) and how to tell them apart from opinions.

At the end of this tutorial you will be able to:

1. Identify the components of a scientific argument
2. Evaluate the strength of a scientific argument and its components

A good ticket out the door is to have students write down their own definition of Scientific Argument after having seen the videos and heard the definition.

Scientific Argument Tutorial

Part 2 of 5 – The “Claim” of Scientific Argument

Knowing that a scientific argument must have claim, evidence and reasoning, let’s examine the first component: the claim. **Claims are statements about a phenomena or event.** However some claims are obviously stronger and more persuasive than others. What might make a claim stronger or more persuasive than another? Consider the claim statements from the barefoot running videos. Which claims are strong? Which are weak?

As students discuss claims ask “What do these claims have in common...all are statements. However, how do we determine which are stronger? What helps to make some stronger? Remind students of the question and ask if these claims each address the question asked? Which statements are also clear and understandable? How could the weaker claims be strengthened?

Question: Should runners run barefoot or with shoes?

- A. We have this idea that in order to run all you need are shoes but actually you just need feet. [Rank 2](#)
- B. Barefoot running would be great if we grew up barefoot, but we didn’t so people should not run barefoot. [Rank 1](#)
- C. Individuals who don’t land on their heel may be less likely to experience stress injuries. [Rank 3](#)
- D. We weren’t born to run on pavement. [Rank 4](#)

CLASS

Rank the claim statements according to their strength (1 is the strongest claim). Remember to consider the question being asked. What did they have in common?

Strong Claim Characteristics

1. Answers the question *asked*
2. Stands alone by rephrasing the question in a complete sentence
3. Explains a cause and effect (“My claim is _____ because _____.”)

You might have thought that the strongest claims were complete thoughts or sounded believable. In a scientific argument, strong, persuasive claims have certain characteristics.

- [Teacher write Poster or Post it the definition of claim and the three characteristics for strong claims. \(You will be referring back to them so hang it in your classroom where visible\)](#)

Scientific Argument Tutorial

In your student pages you will find a description of a scientific investigation conducted by students in a science classroom. It includes a chart of data collected by the students. Evaluate the strength of the students' claim statements using the Strong Claim Characteristics as a guide.

Together as a class read the scientific investigation, the data collected, and the question being investigated found in the student pages. (OR teacher can decide to DEMO this investigation for the class)

- You may want to show an overhead of the top half of the student page and wait to hand out the full SP until you have gone over it as a class.
- Facilitating questions include:
 - "What is the definition of claim and do these claims meet it?,"
 - Do these claims meet the characteristics of a strong claim statement?"
 - "Which ones and Why?"

Evaluating Claims as a Class
Part 2 of 5 The "Claims" of Scientific Argument

Question: Did a chemical reaction occur when vinegar and baking soda were mixed together?

Student Data						Answer Yes or No, in each column	
Student Name	Initials	Initials after 1st observation	Change in temperature	Change in mass	Other Observations	Does Claim explain the question asked?	Does Claim explain the cause and effect relationship?
Answer #1	1	1B	1C (1)	1D (1)	1E (1)	1F (1)	1G (1)

Claim Statements Given

a) I think a chemical reaction did occur because a gas was produced.
 b) A chemical reaction did occur in this experiment.
 c) There was a change in temperature.

Answer the following questions:
 Which Claim is the strongest? (circle one) A, B, C Why?
 Which Claim is the weakest? (circle one) A, B, C Why?

CLASS

Think, Pair Share: Discuss with your group the example investigation and claims found on the **B-Evaluating Claims as a Class** sheet. Answer the questions that follow. Afterward discuss your answers as a class.

Questions to consider with your group and discuss as a class:

- Which claim(s) answer the question asked?
- Which claim(s) are causal (include why or because)?
- Which claim(s) are the most clear, restating the question asked?
- Which is the best claim statement for the data provided?
- Which claim is the strongest? Why?

Did you realize that the strongest claims are those with multiple boxes checked (both answer a question AND explain a cause/effect)? The weakest claims had only one box on the table checked. On your own, analyze the claim statements from a second student investigation.

STUDENT

Evaluate the claim statements for the unknown substances investigation on the **C-Evaluating Claims as an Individual** sheet. Answer the questions that follow on the bottom of the sheet.

- Together as a class read the next scientific investigation the data collected, and the question being investigated FOUND IN THE STUDENT PAGES. (AND/OR teacher can decide to DEMO this investigation for the class during this discussion).*
- You may want to show an overhead of the top half of the student page and wait to hand out the full SP until you have gone over it as a class.

Scientific Argument Tutorial

Name _____ Teacher _____ Period _____
Date _____

Evaluating Claims as an Individual
Part 2 of 3: The "Claim" of Scientific Argument

Example: Soline is a description of a scientific investigation and the data collected by students in a science classroom.
Investigation: School students collected data on two unknown items to find out if they were different substances. The students ran an investigation and collected data on color, melting point, solubility, density and hardness for both items. The data collected is shown in table below.

Student Data Collection for Item #1 and Item #2		Investigation		Density (g/mL)	
Color	Hardness	Solubility (Yes/No)	Melting Point (°C)	Item #1 (g/mL)	Item #2 (g/mL)
Orange to a copper	Orange to a copper	Change for substance	Change for substance	Change for substance	Change for substance
Substance #1	Substance #2	Water (Yes/No) (Yes/No)	Water (Yes/No) (Yes/No)	1.7 (Yes/No)	1.7 (Yes/No)
Yellow	Red	Water (Yes/No) (Yes/No)	Water (Yes/No) (Yes/No)	1.7 (Yes/No)	1.7 (Yes/No)
Substance #1	Substance #2	Water (Yes/No) (Yes/No)	Water (Yes/No) (Yes/No)	1.7 (Yes/No)	1.7 (Yes/No)

Question: Are Item #1 and Item #2 the same substance or different substances?

Claim Statements Given	Does Claim answer the question ASKED? Yes or No	Does Claim explain the cause and effect? Yes or No	Is the Claim a complete answer? Yes or No	Claim Total Score (Count # 1-3)
(1) The two substances are both stuff, but they are different types.				
(2) Yes, they are different.				
(3) Substance #1 and #2 are different because one looks like something you eat and the other looks like something you wash with.				
(4) Substance #1 and #2 are different substances because they have different properties.				

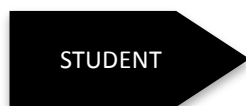
Answer the following questions:
1. Which Claim is the strongest claim: (circle one) a, b, c, d Why?
2. Which Claim is the weakest claim: (circle one) a, b, c, d Why?

The next activity will be referred to often in the tutorial, as such is you will need to walk them through the investigation as a class.

- Be sure to answer the questions at the bottom of the student page...Which is the strongest claim and WHY (because it meets multiple characteristics that make up a strong claim— answers question asked it is causal, and it can stand alone.)

Consider this question: Which student claim in this assignment is the strongest? To help determine this, write your own claim by answering this question using the Strong Claim Characteristics as a guide. Practice writing your own claim and share it with the class. What sentence starters are helpful when writing your own claim?

- Have students fill out the Claim Notes Page. Bullet #3 is an example of a sentence starter (One example for box on SP definition page). Another possible example sentence starter is “ ___ occurs because ___ “



Complete the **D-Scientific Argument Notes: Claims** sheet and share your claims with the class.

Name _____ Teacher _____ Period _____
Date _____

Scientific Argument Notes: Claims
Part 2 of 3

Define Claim:

What are the Characteristics of a Strong Claim?

Fill in the Blanks:
A strong, persuasive claim is different from g(h)_____ because _____

Brainstorm examples of sentence starters for Strong Claim Statements below:

Using the Characteristics of Strong Claims, write your own claim answering the question:
Which argument (A, B, C, D) is the strongest?

In summary, a **strong persuasive claim** is different from opinions or simple facts. It answers a specific question and includes a reason why the answer/solution is correct. However, a persuasive argument does not end with a claim statement, it must be supported by additional information—**Evidence**.

A possible ticket out the door

- “Define Claim”, or
- Write your own for “Who is the best teacher in this school?”

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Part 3 of 5 – The “Evidence” of Scientific Argument

Most people agree that evidence is essential to science and it is key to supporting a scientific claim. However, what counts as evidence can be confusing or hard to determine. What makes one piece of evidence stronger than another? Consider the evidence statements from the barefoot running videos. Which pieces of evidence are strong? Which are weak?

As your discuss evidence statements ask students how they define evidence

Question: Should runners run barefoot or with shoes?

- A. When I ran barefoot, I bruised my feet and for 8 months I had to deal with extreme pain in my feet and legs. Rank 3. (single observation..how can you make it stronger?)
- B. In laboratory tests of 100 runners who have never run barefoot, an average of 60% experienced a stress fracture of the foot or leg after 40 hours of running without shoes. Rank 1.
- C. Humans have been running for almost 2 million years and for most of that, they’ve been running barefoot. Rank 4. (This is an inference not observation)
- D. We studied many runners in the lab and we found that barefoot runners show less impact on their heels than shoe wearing runners. Rank 2. (General no measurements or trends in data given.)

CLASS

Rank the evidence statements according to their strength (1 is the strongest). Discuss as a class the statements that were the strong and weak. What did they have in common?

In your rankings you might have thought that many of the statements made good points and included numbers to seem stronger, but which statements were strongest?

- Were all numbers equally helpful as evidence? Why or why not?
- What did the stronger pieces of evidence have in common?

In a scientific argument, strong, persuasive evidence statements have certain characteristics. Evidence consists of trends or patterns in your data that you can see over multiple examples.

Evidence is *not* pure numbers, observations, or raw data. Evidence is the pattern or trend that emerges when the raw data is analyzed.

Scientific Argument Tutorial

DEFINITIONS

Evidence – a trend or pattern from measurements and observations, collected during an investigation, that supports a claim

Trend – the patterns in your numerical data that can be seen over multiple examples

When students begin writing their own evidence, they often use individual data points or numbers.

The focus should be on patterns, statistical trends in the data.

The quality and type of evidence matters; strong evidence supports a claim and makes it more persuasive. What are the characteristics of strong evidence statements?

Strong Evidence Characteristics

1. Includes trends or patterns found in data analysis (Pattern-based)
2. Multiple trials/observations are reported and analyzed (Reliable)
3. Evidence is scientifically correct and appropriate to the question (Accurate)
3. There are enough, more than one, pieces of appropriate evidence (Sufficient)

- Teacher write Poster or Post it the definition of Evidence and the four characteristics for strong evidence statements from above. (You will be referring back to them so hang it in your classroom where visible)

Using these Strong Evidence Characteristics as a guide, let's compare the given evidence statements from the chemical reaction investigation and analyze each for strength.

CLASS

Think, Pair, Share: Discuss with your group the evidence statements found on the *E-Evaluating Evidence as a Class* sheet and fill out the chart. Decide which statement is the strongest. Discuss your choice with your group then answer the questions below. Afterwards, discuss as a class.

Scientific Argument Tutorial

Remind students that they have just looked at this investigation/demo when discussing claims.

Now they will look at evidence statements from the same investigation/demo.

Name		Teacher		Period		
				Date		
Evaluating Evidence as a Class Part 3 of 5: The "Evidence" of Scientific Argument						
Question: Did a chemical reaction occur when vinegar and baking soda were mixed together?						
Student Data						
	Average Balloon Diameter Before (cm)	Average Balloon Diameter After (cm)	Vinegar Initial Temperature	Average Temperature of Vinegar & Baking Soda	Average Change in Temp. (°C)	Group Observations
Average of 5 trials	4	19	22 (°C)	15 (°C)	-7 (°C)	Balloon expanded about 15cm in diameter. Bubbles formed in flask.
Does Evidence Include TRENDS or PATTERNS over multiple trials, repetitions, or groups? (Yes, No, Inconsistent, Inadequate, Inappropriate)						
Are multiple trials, tests or observations used to increase ACCURACY and APPROPRIATENESS for the data and question?						
Is there more than one piece of appropriate evidence?						
(Use this to record your data!)						
	E1	E2	E3	E4	Total	
Given Scientific Evidence a) The vinegar and baking soda reacted with each other and there was a change in temperature. b) When the baking soda and vinegar were mixed together the average temperature decreased about 7°C for all groups. c) See above data chart.						
Answer the following questions: Which Evidence is the strongest: (circle one) <u>a</u> , b, c Why? Which Evidence is the weakest: (circle one) <u>a</u> , b, c Why?						

Discussion Questions:

- Which evidence uses inference (speculation or generalities) and which uses measurement?
- Which evidence includes measurement trends/patterns and which evidence only states numbers?
- Which evidence statement is the strongest? Why?

Did you realize that the strongest evidence statements are those with the most boxes checked (Includes trend/pattern, is accurate and appropriate, and is sufficient in number), while the weakest evidence had only one or none boxes on the chart checked?

Previously, we compared the claims written for a classroom investigation asking the question: Is Substance #1 and Substance #2 the same substance or different substances? On your own, now analyze the students' supporting evidence for this same investigation.

Remind students that they have just looked at this investigation/demo when discussing claims.

Now they will look at evidence statements from the same investigation/demo.



On your own, review the investigation, data collected, and given claim found on the *F-Evaluating Evidence as an Individual* sheet. Choose the best evidence statement that supports the claim. Explain why you chose that statement.

- As you walk around the class, make sure the students fill out the two questions on the bottom of the rubric and answer why. Discuss as a class.

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As you walk between groups ask questions: “What is the difference between evidence and raw numbers? Can you give me an example?” You may also have to remind groups how to read the investigation table to determine if the data is accurate.

Name	Teacher	Period
Date		
Evaluating Evidence as an Individual Part 3 of 5 The “Evidence” of Scientific Argument		
Example: Below is a description of a scientific investigation and the data collected by students conducted in a science classroom.		
Investigation: School students collected data on two unknown items to find out if they were different substances. The students ran an investigation and collected data on color, melting point, solubility, density, and hardness. See both items. The data collected is shown in table below.		
Student Data Collection for Item #1 and Item #2 Class Investigation		
Color (Average for 5 samples)	Hardness (Average for 5 samples)	Solubility Yes/No (One for 5 samples)
Substance #1 Off white or yellow	Soft-Squishy	Water (No); Oil(Yes)
Substance #2 Milk White	Hard	Water(Yes); Oil (No)
Melting Point (°C) (One for 5 samples)	Density (g/mL) (One for 5 samples)	
37 (°C)	0.92 (g/mL)	
100 (°C)	0.78 (g/mL)	
<small>(McNeil & Klopfer, 2012)</small>		
Question: Are Item #1 and Item #2 the same substance or different substances?		
Evidence Given	Does Evidence include TRENDS or patterns over multiple trials, samples, or observations? (e.g. mean, median)	Is the Evidence scientifically ACCURATE? Yes or No
Directions: Evaluate each evidence statement given below by answering yes or no for each question on this rubric. After evaluating each, circle the strongest claim (a, b, or c) and answer the question below.	Is the Evidence reasonable or APPROPRIATE for the data and question given? Yes or No	Is there more than one piece of evidence? (Yes/No)
(a) Our investigation of five identical pieces of the two substances found that the pieces of Substance #1 were all off white or yellow and soft-squishy, while all the pieces of Substance #2 were white and hard. The average melting point of Substance #1 was 37°C and the average for Substance #2 was 100°C. The average density for substance #1 was 0.92 (g/mL) and 0.78 (g/mL) for substance #2.		
(b) The data table is my evidence that they are different substances.		
(c) With their properties like density, Substance #1 was squishy, denser than Substance #2. Substance #2's melting point was over 100 degrees Celsius, while Substance #1 kind of started at 37 degrees Celsius.		
Which evidence is the strongest? (circle one) a, b, c Why?		

Take time to go over the evidence statements as a class. Remember to refer to the definitions of claim, evidence and trend and the four characteristics of evidence. Ask facilitating question like:

- “Why did you score it that way?”
- “What trend did you notice?”
- “Was the evidence appropriate and in what way?”
- “What is the difference between the evidence statements?”
- “How could the evidence statements be stronger?”

In summary, a strong claim with supporting evidence is different from an idea that is opinion-based. However, a persuasive scientific argument does not end with a claim and evidence. A scientific argument needs to include the link of scientific content or scientific fact—**Scientific Reasoning**.



Complete the **G-Scientific Argument Notes: Evidence** sheet.

Have students look for examples of evidence sentence starters as they continue through the unit.

Examples include:

- We ran ___ trials and found the following trends ___”
- “In ___ repeated identical investigations we found on average that ___”
- “In our investigation we found that after analyzing five trials, a pattern emerged showing ___
- “In our experiment/investigation we found ___”
- “My evidence is that ___

A good ticket out the door is to have students write down their own definition of evidence and trend after having practiced identifying each.

Name	Teacher	Period
Date		
Scientific Argument Notes: Evidence Part 3 of 5 The “Evidence” of Scientific Argument		
Define Evidence:		
Define Trend:		
Define Data:		
What are the Characteristics of Strong Evidence Statements?		
1)		
2)		
3)		
Brainstorm examples of Sentence Starters for Strong Evidence Statements below:		

Scientific Argument Tutorial

Part 4 of 5 – The “Reasoning” of Scientific Argument

We have discussed the first two components of scientific argument: claim and evidence. Now we will address the third, and possibly the most critical, component of the scientific argument: **Scientific Reasoning.**

What qualities might make some reasoning statements stronger than others? Let’s consider the reasoning statements from the barefoot running arguments. Which of the statements are strong? Which are weak? Why?

In Scientific Argumentation research studies have shown that students understand how evidence fits with a claim, but the connection of underlying scientific concepts (reasoning) with claim and evidence is the hardest. Yet scientific reasoning is the most important component of the scientific argument because it is what facilitates student sense making. It requires the understanding and application of a science concept to an investigation. As a result, time should be taken to make sure that students understand this component.

Question: Should runners run barefoot or with shoes?

- A. When you land on your heel there’s a rapid **force** created between the ground and your foot. **Rank 2**
- B. Barefoot runners land toward the front of their foot and then let the heel come down afterwards, which is different than runners wearing shoes, so it is better. **(Rank 3. None)**
- C. **Science has showed** that doing the same motion over and over can cause stress to the human body. Running causes repeated strikes (over and over) on the heel of the foot on pavement and thus can result in stress to the body. **Rank 1 (strong logic as it follows the template “In science we have learned that ____ and because of this ____, then ____, therefore ____”)**

CLASS

Rank the reasoning statements according to their strength (1 is the strongest). Discuss as a class the statements that were strong and weak. What did they have in common?

In your rankings of the reasoning statements, you might have thought that many had valid points, but were some stronger than others?

- What did the stronger reasoning statements have in common?
- What type of vocabulary did the stronger reasoning statements use?
- Was there a connection to the original claim or idea?

Scientific Argument Tutorial

Scientific reasoning gives an argument its strength. Scientific reasoning explains why; what it all means. The reasoning explains the science that was occurring and what it means to the question. Specifically, the **reasoning is the science content or facts that links the evidence to the claim you made.**



Reasoning – The justification that links the evidence to the claim. It explains why the evidence supports the claim.

Scientific Reasoning – The justification that links the evidence to the claim. It explains why the evidence supports the claim. It is a description of known science fact or knowledge that explains the connection between given evidence and a claim.

Strong reasoning links a claim and evidence, giving an argument justification and context within the natural world. What are the characteristics of strong reasoning statements?

Strong Scientific Reasoning Characteristics

1. Includes *appropriate science vocabulary* or terms
2. Completely explains the *science facts* (big idea) that connect the evidence and claim
3. Answers why and/or how the patterns of evidence occurred and support the claim

Teacher create Poster or Post it with the definition of Reasoning and the three characteristics for strong reasoning statements. (You will be referring back to them so hang it in your classroom where visible)

Scientific Argument Tutorial

Let's compare and analyze the reasoning statements for the chemical reaction investigation. Analyze the student's scientific reasoning for this investigation using the Strong Scientific Reasoning Characteristics as a guide.



Think, Pair, Share: Discuss with your group the reasoning statements found on the *H-Evaluating Reasoning as a Class* sheet. Fill out the chart individually. Decide which statement is the strongest, and discuss your choice with your group.

Name		Teacher		Period	
				Date	
Evaluating Reasoning as a Class <i>Part 4 of 5 The "Reasoning" of Scientific Argument</i>					
Question: Did a chemical reaction occur vinegar and baking soda were mixed together?					
Answer Yes or No (circle one)					
Include appropriate science vocabulary?					
Explain the science facts (Big Ideas) and how they connect to the claim?					
Answer why or how the evidence supports claim? (Connect E & C)					
Total Score (Add from all columns for Student)					
Y1 Y2 Y3 Total					

Student Data					
Balloon Diameter Before (cm)	Balloon Diameter After (cm)	Vinegar Initial Temperature	Temperature of Vinegar & Baking Soda	Change in Temp (°C)	Group Observations
Average of 5 Balloons	4	19	22 (°C)	13 (°C)	-7 (°C)

Given Scientific Reasoning

a) I think a chemical reaction did occur. The reason for that is the vinegar and baking soda reacted with each other and there was a change in temperature. Therefore a chemical reaction occurred.

b) As we have learned in science class, in a chemical reaction something new is made. In this case gas bubbles (carbon dioxide) were produced. Evidence of a chemical reaction also includes formation of a gas and temperature change.

Answer the following questions:

1. Which Reasoning statement is the strongest: (circle one) a, b Why?
2. Which Reasoning statement is the weakest: (circle one) a, b Why?

Take time to go over the reasoning statements as a class. Remember to refer to the definition of reasoning and the three characteristics of reasoning. Ask facilitating questions like: "Do these reasoning statements fit with the definition and characteristics of strong reasoning?", "Do these reasoning statements fit with your understanding of the science of chemical reactions? Are the big science ideas clearly expressed?"

During discussion remember to ask students to elaborate on their thinking. Ask questions like "Why do you think that?", "Does anyone disagree with that?" and "Why?"

Discussion Questions:

- Which statement(s) used appropriate science vocabulary?
- Was a scientific "Big Idea" explained?
- Which statement(s) linked the claim and evidence?
- Which reasoning statement is the strongest? Why?

Once again you should have noticed that the strongest reasoning statements are those with the most boxes checked (appropriate science vocabulary, scientific big idea explanation, explaining why or how the big idea connects the evidence and claim) and the weakest reasoning had none or one box on the rubric checked.

Previously, you compared the claims and supporting evidence written after a classroom investigation that asked the question: Is Substance #1 and Substance #2 the same substance or different substances? On your own, now analyze students' scientific reasoning for this same investigation.

Scientific Argument Tutorial

STUDENT

Review the investigation, data collected, given claim and evidence found on the *I-Evaluating Reasoning as an Individual* sheet. Choose the best reasoning statement. Explain why you chose that statement.

As you walk around the class, make sure the students fill out the two questions on the bottom of the rubric and answer why.

Discuss this as a class.

Name		Teacher		Period	
				Date	
Evaluating Reasoning as an Individual Part 4 of 5 The "Reasoning" of Scientific Argument					
Question: Are Item #1 and Item #2 the same substance or different substances?					
Given Scientific Reasoning	Includes appropriate science vocabulary? Yes or No	Explains the science facts (big ideas) behind the evidence and Claim? Yes or No	Connects Claim and Evidence and/or answers why or how the evidence supports the claim Yes or No	Reasoning Total Score Add # yes	
Directions: Evaluate each evidence statement given below by answering yes or no for each question on this rubric. After evaluating each, answer the questions below.					
(a) Color, hardness, solubility, melting point and density are all properties of matter. Because the two substances have different properties, I know they are different.					
(b) Because of the data I collected, I know that #1 and #1 are not the same substance.					
(c) In science I have learned that properties are characteristics of a substance that are independent of the amount of the sample. The properties are solubility, density and melting.					
(d) Because in science we know that all matter is defined by its properties (density, solubility, melting/boiling points) and that different matter has different properties. Then if two substances are shown to have different properties, then the two substances must be different.					
Answer the following questions: 1. Which scientific reasoning statement is the strongest: (circle one) a, b, c, d Why?					
2. Which scientific evidence statement is the weakest: (circle one) a, b, c, d Why?					

In summary, strong scientific arguments are persuasive and include three critical components: claims, evidence, and reasoning. The quality of these three components strengthens the argument that is answering a scientific question. You will now record notes on scientific reasoning and afterward you will put it all together and evaluate whole arguments for strength.

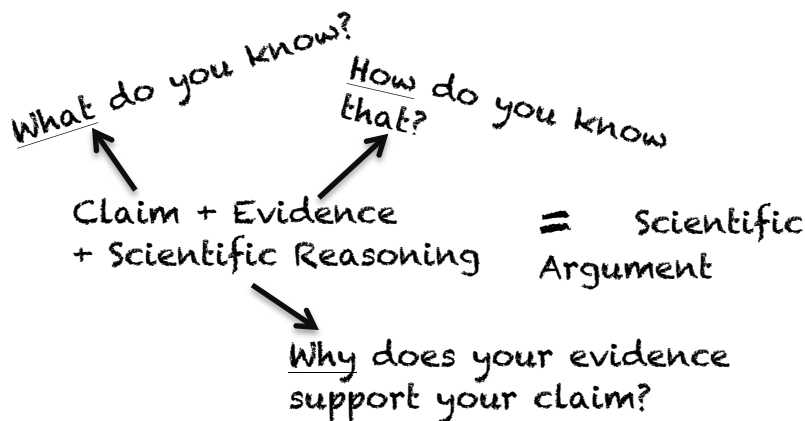
STUDENT

Complete the *J-Scientific Argument Notes: Reasoning* sheet.

Have students write the definitions for Reasoning in their student pages. Also have them look for examples of reasoning sentence starters as they continue through the unit. (TE includes this list). Some examples include:

- "Because in Science..."
- "We have learned in science that ____"
- "Science shows us that____"

A good ticket out the door is to have students write their own definition of scientific reasoning after having identified it and practiced evaluating it.



Scientific Argument Tutorial

Part 5 of 5 - Evaluating Complete Scientific Arguments

In this tutorial you have learned to identify the components of a strong scientific argument (claim, evidence, and reasoning) and to evaluate the strength of each component individually. Now we will put it all together and evaluate arguments as a whole.

As a class, let's look at the following student arguments. These were written after the students completed an investigation in class to answer the question "How does exercise affect your pulse rate?". Identify the individual components of the student's argument (underline the claim, number the pieces of evidence, and circle the reasoning statement) and evaluate the strength of each. Ultimately, you will compare the two arguments and determine which is stronger and why?

Read the arguments as a class. Have the class identify the claim and evidence statements (and ask what is left over). Introduce the underline, number, circle method of identifying the components of claim and evidence here by placing the two arguments on an overhead and as students identify each then underline the claim, number the evidence...at end circle the reasoning as being the difference between the two arguments (this is the key to this exercise-to identify what is missing, the reasoning). Explicitly tell students that this underline, number and circle method is a way to graphically identify the pieces of a scientific argument and they will be practicing it.



Think, Pair, Share: Identify the components of the argument (claim, evidence, and reasoning). Then use the rubric on the *K-Evaluating an Argument as a Class* sheet to evaluate the quality of each component. Answer the questions that follow the second

As you walk around the class, make sure the students fill out the two questions on the bottom of the rubric and answer why. Discuss as class.

Name		Teacher		Period	
				Date	
Evaluating Arguments as a Class Part 5 of 5 Evaluating Complete Scientific Arguments					
Question: How does exercise affect your pulse rate?			Answer: Yes or No in each column		
<p>Student Argument #1</p> <p>The pulse rate increased. In class we did a lab where I measured my pulse rate before and after I exercised. I did jumping jacks for 30 seconds. Before I exercised my pulse rate was 70 and after I exercised it was 95. The pulse went up because I was moving my arms and legs and sweating. I was breathing more and my heart was beating faster. If we were just sitting down my pulse wouldn't go up as much.</p>			Does this argument contain a claim? (Yes/No/Not clear)	Does this argument contain evidence? (Yes/No/Not clear)	Does this argument contain reasoning? (Yes/No/Not clear)
			Is this claim a complete sentence? (Yes/No/Not clear)	Are all pieces of evidence numbered? (Yes/No/Not clear)	Are all reasoning statements circled? (Yes/No/Not clear)
Numbered sentences: _____ Circled sentences: _____ Underlined sentences: _____			Total Score: _____ (100% = all components identified)		

Name		Teacher		Period	
				Date	
Evaluating Arguments as a Class Part 5 of 5 Evaluating Complete Scientific Arguments					
Question: How does exercise affect your pulse rate?			Answer: Yes or No in each column		
<p>Student Argument #2</p> <p>Our pulse rates increased after exercising because we were using energy. Our group completed five trials where one student measured their pulse rate before and after exercising and did jumping jacks for 30 seconds. The mean pulse rate before exercise was 62 beats a minute and after exercise increased to 84 beats a minute. We learned in science class that when you exercise, your muscles burn stored energy and need more oxygen. Your blood brings the oxygen to your muscles. The harder you exercise, the faster your heart beats to deliver the oxygen.</p>			Does this argument contain a claim? (Yes/No/Not clear)	Does this argument contain evidence? (Yes/No/Not clear)	Does this argument contain reasoning? (Yes/No/Not clear)
			Is this claim a complete sentence? (Yes/No/Not clear)	Are all pieces of evidence numbered? (Yes/No/Not clear)	Are all reasoning statements circled? (Yes/No/Not clear)
Numbered sentences: _____ Circled sentences: _____ Underlined sentences: _____			Total Score: _____ (100% = all components identified)		

Discussion Questions for Each Argument:

- Are you persuaded to the writer's way of thinking? Why or why not?
- Does it meet the characteristics of each component of an argument?
- Is the evidence appropriate and/or logical with the claim?
- How can you improve the weaker argument?

Scientific Argument Tutorial

During discussion remember to ask students to elaborate on their thinking. Ask questions like “Why do you think that?”, “Does anyone disagree with that?” and “Why?”, “Does this science reasoning fit with your understanding of the process of science?”

Now that you have evaluated an argument as a class (identifying the components and determining their argumentative strength), you are going to try it on your own. In your student pages you will find two different arguments for the question “Why do you think penguins are able to survive in their natural environment?” Read, compare, and evaluate each of the arguments for strength. Determine which one is the stronger argument and why.

Compare and evaluate the scientific arguments found on the *L-Evaluating Arguments as an Individual* sheet. Identifying the components of each argument, then rank each on the rubric. Answer the questions that follow the second argument.




Name	Teacher	Period
		Date

Evaluating Arguments as an Individual
Part 5 of 8 Evaluating Complete Scientific Arguments

Question: Why do you think Penguins are able to survive in their natural environment?

Penguin Argument #1:




They live in the Antarctic because they like to live where it is cold. Penguins always live somewhere that has lots of snow and ice and water. They would not be able to live someplace that was warm and did not have any snow. For example, they could not live in Hawaii because it is too warm there. The Antarctic has lots of snow and ice and water, which is why they are able to live there.

Answer Yes or No in each column		
Does Claim answer THE question asked?		
Does Claim explain the cause and effect of an event (i.e., because...)?		
Is this Claim a complete sentence?		
Does Evidence include TEND or pattern over multiple Claims, including a claim of direct inference?		
Do the mean, median, mode, frequency, range		
Is the Evidence RELEVANT-ACCOUNT?		
Is the Evidence reasonable or APPROPRIATE for the claim and question asked?		
Is there sufficient evidence?		
Includes appropriate science vocabulary		
Supports the evidence from the data/linked the Evidence and Claim correctly		
Answers why or how the Evidence supports claim (connects E & C)		
Total Score		

Name	Teacher	Period
		Date

Question: Why do you think Penguins are able to survive in their natural environment?

Penguin Argument #2:



Penguins can live in their natural environment (the Antarctic) because they have adaptations for it. Around 40 million penguins live in the Antarctic. They all have webbed feet and flippers that allow them to swim through the water to search for food and escape predators. They also have hard, strong beaks that allow them to catch their food. Their bodies are covered with feathers. The feathers repel water and keep them warm in the cold environment. Adaptations are characteristics that allow an animal to survive in its environment. Getting food and staying warm are both necessary for animal and its species to live.

Answer Yes or No in each column		
Does Claim answer THE question asked?		
Does Claim explain the cause and effect of an event (i.e., because...)?		
Is this Claim a complete sentence?		
Does Evidence include TEND or pattern over multiple Claims, including a claim of direct inference?		
Do the mean, median, mode, frequency, range		
Is the Evidence RELEVANT-ACCOUNT?		
Is the Evidence reasonable or APPROPRIATE for the claim and question asked?		
Is there sufficient evidence to support the claim?		
Includes appropriate science vocabulary		
Supports the evidence from the data/linked the Evidence and Claim correctly		
Answers why or how the Evidence supports claim (connects E & C)		
Total Score		

Answer the following questions: Which argument (#1 or #2) is the strongest? Why?

Making an argument is one of the fundamental things we do as a society. People make arguments everyday. Basic argumentation means claiming that something is true and trying to persuade others to agree with your claim by presenting evidence and reasoning to support it.

Learning to identify and evaluate strong arguments is important for all citizens. Not only do scientists make arguments based on science, engineers do as well. Solutions in engineering are informed by scientific evidence and reasoning and presented to clients through argumentation. Through this tutorial you have learned how to identify and evaluate strong scientific arguments. This will help you increase your critical thinking skills and become a well-informed citizen.