

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**.



DEFINITIONS

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

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 *Scientific Argument Notes* sheet. Afterwards you will discuss your answers as a class.

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| Name | Teacher | Period |
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Scientific Argument Notes
Part 1 of 5 *What is Argument in Science?*

Define SCIENTIFIC ARGUMENTATION:

| | |
|---------------------|---------------------|
| Notes from Video #1 | Notes from Video #2 |
|---------------------|---------------------|

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

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.

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

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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?

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.
- B. Barefoot running would be great if we grew up barefoot, but we didn’t so people should not run barefoot.
- C. Individuals who don’t land on their heel may be less likely to experience stress injuries.
- D. We weren’t born to run on pavement.

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?

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

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* _____.”)

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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.

CLASS

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

| Name _____ | | Teacher _____ | | Period _____ | | | | | | | | | | | | | | | | | | | | | |
|---|------------------------------|-----------------------------|-----------------------------|---|----------------------|--|----|----|-------|--|------------------------------|-----------------------------|-----------------------------|--------------------------------------|----------------------|--------------------|---------------------|---|----|---------|---------|---------|--|---|--|
| | | | | Date _____ | | | | | | | | | | | | | | | | | | | | | |
| 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? | | | | Answer Yes or No, in each column. | | | | | | | | | | | | | | | | | | | | | |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="6" style="text-align: center;">Student Data</th> </tr> <tr> <th></th> <th>Balloon Diameter Before (cm)</th> <th>Balloon Diameter After (cm)</th> <th>Vinegar Initial Temperature</th> <th>Temperature of Vinegar & Baking Soda</th> <th>Change in Temp. (°C)</th> <th>Group Observations</th> </tr> </thead> <tbody> <tr> <td>Average of 5 Groups</td> <td>4</td> <td>19</td> <td>22 (°C)</td> <td>15 (°C)</td> <td>-7 (°C)</td> <td>Balloon expanded about 15cm in diameter; Bubbles formed in flask</td> </tr> </tbody> </table> | | | | 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 Groups | 4 | 19 | 22 (°C) | 15 (°C) | -7 (°C) | Balloon expanded about 15cm in diameter; Bubbles formed in flask | Does Claim answer the question ASKED? Does Claim explain the cause and effect "...because..."? Is the Claim a complete sentence? Test Score <small>(Add Yes in all columns, not shaded)</small> | |
| 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 Groups | 4 | 19 | 22 (°C) | 15 (°C) | -7 (°C) | Balloon expanded about 15cm in diameter; Bubbles formed in flask | | | | | | | | | | | | | | | | | | | |
| 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) <u>a</u> , b, c Why? Which Claim is the weakest: (circle one) <u>a</u> , b, c Why? | | | | <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>C1</th> <th>C2</th> <th>C3</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;"> </td> <td style="text-align: center;"> </td> <td style="text-align: center;"> </td> <td style="text-align: center;"> </td> </tr> <tr> <td style="text-align: center;"> </td> <td style="text-align: center;"> </td> <td style="text-align: center;"> </td> <td style="text-align: center;"> </td> </tr> </tbody> </table> | | C1 | C2 | C3 | Total | | | | | | | | | | | | | | | | |
| C1 | C2 | C3 | Total | | | | | | | | | | | | | | | | | | | | | | |
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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 *Evaluating Claims as an Individual* sheet. Answer the questions that follow on the bottom of the sheet.

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| Name | Teacher | Period |
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Evaluating Claims as an Individual
Part 2 of 5 The "Claim" of Scientific Argument

Example: Below 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 Class Investigation | | | | | |
|---|----------------------------------|-------------------------------------|--|---|---|
| | Color (Average for 5 samples) | Hardness (Average for 5 samples) | Solubility Yes/No (Average for 5 samples) | Melting Point (°C) (Average for 5 samples) | Density (g/mL) (Average for 5 samples) |
| Substance #1 | White | Soft | Water (Yes), Oil (Yes) | 37 (°C) | 0.92 (g/mL) |
| Substance #2 | Yellow | Hard | Water (No), Oil (No) | 105 (°C) | 2.74 (g/mL) |

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 "BECAUSE" ? Yes or No | Is the Claim a complete sentence? Yes or No | Claim Total Score (Count # yes) |
|--|--|--|--|---------------------------------|
| (a) The two substances are both stuff, but they are different types. | | | | |
| (b) Yes, they are different. | | | | |
| (c) Substance #1 and #2 are different because one looks like something you eat and the other looks like something you wash with. | | | | |
| (d) Substance #1 and #2 are different substances because they have different properties. | | | | |

(Schell & Keech, 2012)

Answer the following questions:

- Which Claim is the strongest claim: (circle one) a, b, c, d Why?
- Which Claim is the weakest claim: (circle one) a, b, c, d Why?

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?



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

| | | |
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| Name | Teacher | Period |
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Scientific Argument Notes: Claims
Part 2 of 5

Define Claim:

What are the Characteristics of a Strong Claim?

- 1)
- 2)
- 3)

Fill in the Blanks:
A strong, persuasive claim is different from a(n) _____ 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**.

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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?

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.
- 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.
- C. Humans have been running for almost 2 million years and for most of that, they've been running barefoot.
- D. We studied many runners in the lab and we found that barefoot runners show less impact on their heels than shoe wearing runners.

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

Data – single numbers, measurements or observations from one trial

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)

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 *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

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| Name _____ | | Teacher _____ | | Period _____ | | |
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| 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. |
| 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? _____ | | | | | | |
| Does Evidence include TREND or pattern over multiple trials, samples, or observations (e.g., mass, motion, color, frequency, range)? Are multiple trials, tests or observations reported and analyzed (RELIABLE)? Is the Evidence ACCURATE and/or APPROPRIATE for the data and question? Is there more than one piece of appropriate evidence (SUFFICIENT evidence)? (Add Yes in all columns, not shaded) | | | | | | |
| | E1 | E2 | E3 | E4 | Total | |
| | | | | | | |

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.



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

Scientific Argument Tutorial

| | | |
|------|---------|--------|
| 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 for 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 (Ave. for 5 samples) Water (W); Oil(O) | Melting Point (°C) (Ave. for 5 samples) | Density (g/ml) (Ave. for 5 samples) |
| Substance #1 | Off White or Yellow | Soft/Plastic | Water (W); Oil(W) | 37 °C | 0.92 (g/ml) |
| Substance #2 | Milk White | Hard | Water(W); Oil (No) | 100 °C | 0.74 (g/ml) |

(McNeil & Kessler, 2012)

| Question: Are Item #1 and Item #2 the same substance or different substances? | | | | | |
|--|--|---|---|--|--|
| Evidence Given | Does Evidence include TRENDS or pattern over multiple trials, samples, or observations? (e.g. mean, median) Yes or No | Is the Evidence scientifically ACCURATE? Yes or No | Is the Evidence reasonable or APPROPRIATE for the data and question given? Yes or No | Is there more than one piece of appropriate evidence? (INDUCTION) Yes or No | Evidence Total Score (Add #1 yes for evidence columns) |
| <p>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.</p> <p>(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/Plastic, 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 0.74 (g/ml) for substance #2.</p> <p>(b) The data table is my evidence that they are different substances.</p> <p>(c) With their properties like density, Substance #1 was <i>opposite</i> denser than Substance #2. Substance #2's melting point was over 100 degrees Celsius, while Substance #1 kind of started at 37 degrees Celsius.</p> <p>Which evidence is the strongest? (circle one) a, b, c Why?</p> | | | | | |

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**.

STUDENT

Complete the *Scientific Argument Notes: Evidence* sheet.

| | | |
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| Name | Teacher | Period |
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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?

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.
- 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.
- 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.

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

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.

CLASS

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

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| Name | | Teacher | | Period | |
| | | | | Date | |

Evaluating Reasoning as a Class
Part 4 of 5: The "Reasoning" of Scientific Argument

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

| Student Data | | | | | | Answer Yes or No (check column) |
|------------------------------|-----------------------------|---------------------|-----------------------------------|----------------------|--------------------|--|
| Balloon Diameter Before (cm) | Balloon Diameter After (cm) | Vinegar Temperature | Vinegar & Baking Soda Temperature | Change in Temp. (°C) | Group Observations | |
| Average of 5 Groups | 4 | 19 | 22 (°C) | 15 (°C) | -7 (°C) | Balloon expanded about 13cm in diameter; Bubbles formed in fluid |

| | | | |
|--|--|---|---|
| Included appropriate science vocabulary? | Explains the scientific "Big Idea" and how it connects the evidence and claim correctly? | Answers why and how the evidence supports claim? (Connects E & C) | Total Score (Add Yes in all columns and divide) |
| R1 | R2 | R3 | Total |

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:

- Which Reasoning statement is the strongest: (circle one) **a**, **b** Why?
- Which Reasoning statement is the weakest: (circle one) **a**, **b** 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 *Evaluating Reasoning as an Individual* sheet. Choose the best reasoning statement. Explain why you chose that statement.

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|------|---------|--------|
| Name | Teacher | Period |
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Evaluating Reasoning as an Individual
Part 4 of 5 The "Reasoning" of Scientific Argument

| 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 addresses 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. | | | | |

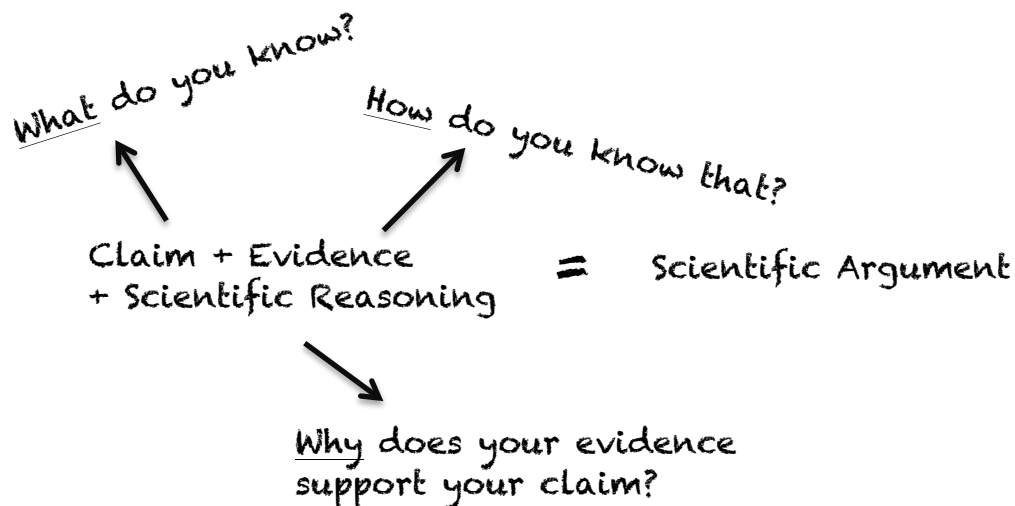
Answer the following questions:

- Which scientific reasoning statement is the strongest: (circle one) a, b, c, d
Why?
- 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 *Scientific Argument Notes: Reasoning* sheet.



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?



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

| 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? | | | | | |
| Student Argument #1 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. | | | Answer Yes or No in each column | | |
| Does Claim answer THE question asked? Does Claim include the cause and effect of an event (e.g., "because...")? Is this Claim a complete sentence? Does Evidence include REASON or address over multiple trials, samples, or observations without 6.0-min, multiple trials, frequency, range Are multiple trials, tests or observations reported and analyzed (RELIABILITY) Is this Evidence relevant to the CLAIM? Is there more than one piece of appropriate evidence? Includes appropriate scientific vocabulary Explains how the Evidence leads to the Claim (REASONING) Answers why or how the Evidence supports claim (CONNECT & C) | | | C1 C2 C3 Underlined sentences E1 E2 E3 Numbered sentences R1 R2 R3 Circled sentences Total Score (66% Yes in all columns not shaded) | | |

| Name | | Teacher | | Period | |
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| Evaluating Arguments as a Class Part 5 of 5 Evaluating Complete Scientific Arguments | | | | | |
| Question: How does exercise affect your pulse rate? | | | | | |
| Student Argument #2 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 94 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. | | | Answer Yes or No in each column | | |
| Does Claim answer THE question asked? Does Claim include the cause and effect of an event (e.g., "because...")? Is this Claim a complete sentence? Does Evidence include REASON or address over multiple trials, samples, or observations without 6.0-min, multiple trials, frequency, range Are multiple trials, tests or observations reported and analyzed (RELIABILITY) Is this Evidence relevant to the CLAIM? Is there more than one piece of appropriate evidence? Includes appropriate scientific vocabulary Explains how the Evidence leads to the Claim (REASONING) Answers why or how the Evidence supports claim (CONNECT & C) | | | C1 C2 C3 Underlined sentences E1 E2 E3 Numbered sentences R1 R2 R3 Circled sentences Total Score (66% Yes in all columns not shaded) | | |
| Answer the following questions: Which argument (#1 or #2) is the strongest? Why? | | | | | |

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

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 *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.

| | | | | | | | | | | |
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| Name _____ | | Teacher _____ | | Period _____ | | | | | | |
| | | | | Date _____ | | | | | | |
| Evaluating Arguments as an Individual Part 5 of 5 Evaluating Complete Scientific Arguments | | | | | | | | | | |
| Question: Why do you think Penguins are able to survive in their natural environment? | | | | | | | | | | |
| Answer Yes or No in each column | | | | | | | | | | |
| <p>Penguin Argument #1:</p>  <p>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.</p> | | <p>Does Claim meet the criteria asked? (Yes/No/Unsure) (E.g., "because...")</p> <p>Does Claim contain a complete sentence?</p> <p>Does Evidence include FEED or actions one might take, samples, or observations with the appropriate units, methods, frequency, range, etc. (E.g., "I saw...")</p> <p>Is the Evidence clearly labeled/identified?</p> <p>Is the Evidence relevant to the claim?</p> <p>Is there more than one piece of appropriate evidence? (YES/NO/Unsure)</p> <p>Includes appropriate source vocabulary</p> <p>Explains in a sentence how the Evidence linked the Evidence and Claim correctly.</p> <p>Answers why or how the Evidence supports claim (Comments: E, C, C)</p> | | | | | | | | |
| | | C1 | C2 | C3 | E1 | E2 | E3 | E4 | R1 | R2 |
| Underlined Sentences | | Numbered Sentences | | Circled sentences | | | | | | |
| (Add Yes in all columns not shaded) | | | | | | | | | | |

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| Name _____ | | Teacher _____ | | Period _____ | | | | | | |
| | | | | Date _____ | | | | | | |
| Evaluating Arguments as an Individual Part 5 of 5 Evaluating Complete Scientific Arguments | | | | | | | | | | |
| Question: Why do you think Penguins are able to survive in their natural environment? | | | | | | | | | | |
| Answer Yes or No in each column | | | | | | | | | | |
| <p>Penguin Argument #2:</p>  <p>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 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.</p> | | <p>Does Claim meet the criteria asked? (Yes/No/Unsure) (E.g., "because...")</p> <p>Does Claim include the terms and units of an argument? (E.g., "I saw...")</p> <p>Does Claim contain a complete sentence?</p> <p>Does Evidence include FEED or actions one might take, samples, or observations with the appropriate units, methods, frequency, range, etc. (E.g., "I saw...")</p> <p>Is the Evidence clearly labeled/identified?</p> <p>Is the Evidence relevant to the claim?</p> <p>Is there more than one piece of appropriate evidence? (YES/NO/Unsure)</p> <p>Includes appropriate source vocabulary</p> <p>Explains in a sentence how the Evidence linked the Evidence and Claim correctly.</p> <p>Answers why or how the Evidence supports claim (Comments: E, C, C)</p> | | | | | | | | |
| | | C1 | C2 | C3 | E1 | E2 | E3 | E4 | R1 | R2 |
| Underlined Sentences | | Numbered Sentences | | Circled sentences | | | | | | |
| (Add Yes in all columns not shaded) | | | | | | | | | | |
| 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.