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Claims, Evidence, and Reasoning

Demystifying data during a unit on simple machines

By Katherine L. McNeill and Dean M. Martin

A fifth-grade class is in the middle of a unit on simple machines. The teacher, Mr. Martin, asks his class, "Does a lever make work easier?" One student responds, "I think it makes work easier," another student disagrees stating, "I think it depends." Mr. Martin then responds, "Each of you has just stated a claim. By the end of our investigations today you will be able to provide evidence to prove which claim is actually correct."

Although students are enthusiastic when engaging in hands-on investigations, they can find it challenging to make sense of their data and to create explanations using evidence from their investigations. We spent a year designing and testing strategies in Mr. Martin's science classroom to better assist his elementary students in constructing and justifying their claims in both science talk and writing. Dr. McNeill collaborated with Mr. Martin to analyze students' writing and videotapes of classroom discussions to identify student strengths and weaknesses and to develop future lessons to meet their needs. Mr. Martin then tested those strategies in his two fifth-grade classrooms. In this article, we describe the strategies we used to help students demystify data and share their results. We use examples from a unit on simple machines to illustrate the process, but the strategies and framework can be used in any science content area.

The Framework

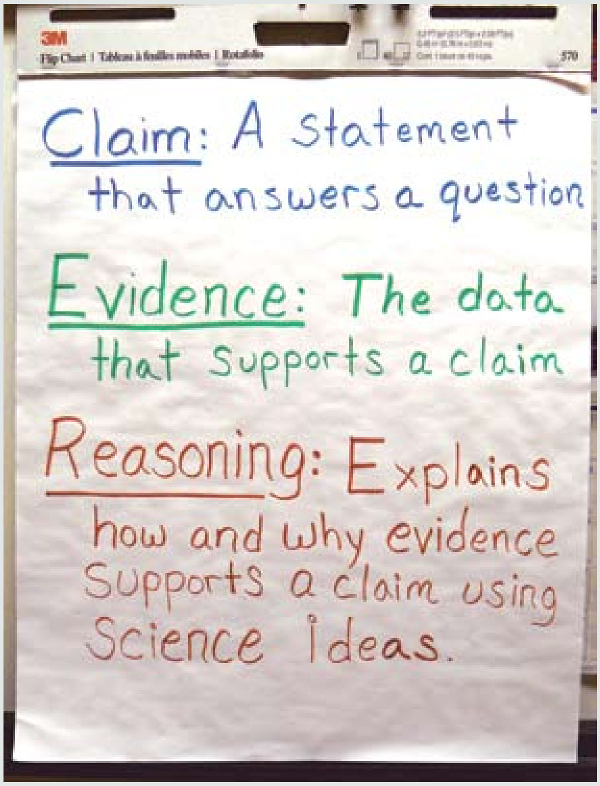
National Science Education Standards (NRC 1996) and reform documents (Michaels, Shouse, and Schweingruber 2008) include a focus on having students use evidence, construct explanations, and engage in argumentation. These meaning-making experiences, whether during classroom discussion or while writing, are essential for effective science instruction. To support students in communicating their explanations and engaging in argumentation, we developed a framework that simplifies these complex practices for students (McNeill and Krajcik 2011).

At the elementary level, we typically introduce the framework as consisting of three components: claim, evidence, and reasoning. The *claim* is a statement that answers a question or problem. *Evidence* is scientific data that supports the claim. The evidence can come from investigations students engage in firsthand or from research conducted online or in books that provide data. Last, *reasoning* provides a justification for why or how the evidence supports the claim. The reasoning often includes scientific principles or science ideas that students apply to make sense of the data.

As students gain more experience and expertise with the framework, we then introduce a fourth component—rebuttal. The *rebuttal* describes an alternative claim and provides counterevidence and counter reasoning for why the alternative claim is not appropriate. Typically, we have not introduced the term *rebuttal* until middle school, though elementary students can debate different claims and evidence in classroom discussions. The claim, evidence, and reasoning framework can support students in productive classroom discussions and science writing because it provides them with a structure to communicate and justify their ideas.

Figure 1.

Visual representations of claim, evidence, and reasoning.



Introducing the Framework

When first introducing the claim, evidence, and reasoning framework, Mr. Martin wanted to make the vocabulary accessible to his fifth graders, so he connected the language to his students' prior ideas and everyday experiences. In the introductory lesson, Mr. Martin began by asking whether anyone had ever heard of the words *claim, evidence,* and *reasoning* before. One student responded, "I saw a TV show that had police in it and they were looking for evidence." Another student said, "I know a reason for something like, the reason we come to school is to learn." Mr. Martin encouraged multiple students to share their ideas to develop a better understanding of their prior ideas about these terms.

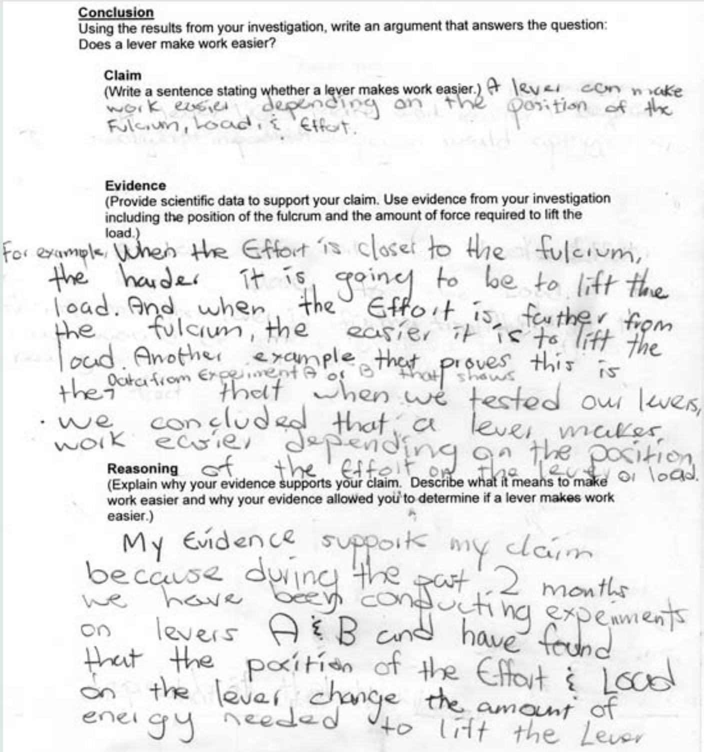
Next, Mr. Martin posed a simple question to connect to their everyday experiences. He asked the class, "How was your weekend?" Clara replied, "I had a great weekend." Mr. Martin followed up by responding, "You did? Well you know something else you just did? You just made a claim." He then went on to explain to his students that a claim is simply an answer to a question. They make claims all the time in their everyday lives. In science class, we often make claims when we answer questions in our investigations. After discussing the term *claim*, Mr. Martin wrote the definition on a poster to provide a visual reminder for all his students (Figure 1).

Then, he asked Clara for proof that she had a great weekend. She responded, "I played with my cousins, we had a party, and we ate ice cream." Mr. Martin then explained that the proof that she just shared was evidence. *Evidence* is data that helps support your claim that you had a good weekend. After adding the definition of *evidence* to the poster, the class discussed other examples of evidence that would support the claim that they had a great weekend.

Last, Mr. Martin discussed the term *reasoning* by stating that reasoning helps you explain why or how your evidence supports your claim. He asked his class to brainstorm a list of things that answered the question: What does it mean to have a great weekend? The class discussed that having a great weekend means that you had fun and that you enjoyed yourself. Certain activities are often evidence that you had fun—like playing, a party, and ice cream—but not always. For example, you could

Figure 2.

Antonio's written scientific argument.


Conclusion
Using the results from your investigation, write an argument that answers the question: Does a lever make work easier?

Claim
(Write a sentence stating whether a lever makes work easier.) A lever can make work easier depending on the position of the fulcrum, load, & effort.

Evidence
(Provide scientific data to support your claim. Use evidence from your investigation including the position of the fulcrum and the amount of force required to lift the load.)
For example, When the Effort is closer to the fulcrum, the harder it is going to be to lift the load. And when the Effort is further from the fulcrum, the easier it is to lift the load. Another example that proves this is the Data from Experiment A or B that shows that when we tested our levers, we concluded that a lever makes work easier depending on the position of the Effort or load.

Reasoning
(Explain why your evidence supports your claim. Describe what it means to make work easier and why your evidence allowed you to determine if a lever makes work easier.)
My Evidence support my claim because during the past 2 months we have been conducting experiments on levers A & B and have found that the position of the Effort & Load on the lever change the amount of energy needed to lift the Lever

eat too much ice cream and your stomach could hurt. So the reasoning needs to explain why or how the evidence supports the claim that you had a great weekend. Mr. Martin added the definition of *reasoning* to the class poster. He explained to his students that they would be using these three components—claim, evidence, and reasoning—when they needed to answer a question or explain the results from their investigations. They would need to support the claims they made in science class, just like they had supported the claim that Clara had a great weekend. The evidence would look different because it would come from their observations and measurements from their science investigations. The reasoning would look different because it would include science ideas. But their arguments would have the same structure.

In this case, the question of "How was your weekend?" was used to introduce the framework. Other teachers we have worked with have used different everyday examples such as: Who is the best basketball player? How long should recess be at our school? What is the most popular song? The examples the teachers used depended on the interests and backgrounds of their students. These everyday examples help students see that they already know how to construct a strong argument and that they can use similar strategies in science.

Designing Classroom Supports

After introducing claim, evidence, and reasoning in this initial lesson, Mr. Martin used the framework throughout the school year to support his students in making sense of and explaining the data they collected in their inquiry investigations, including with a unit on simple machines.

The fifth graders completed two lever investigations as part of the Full Option Science System (FOSS) module Levers and Pulleys (Lawrence Hall of Science 2005). In the investigations, Mr. Martin's students collected data around how the positions of the load and effort, relative to the fulcrum, affect the amount of effort required to move an object. Specifically, the investigations focused on the idea that a lever can make work feel easier, because a lever can reduce the amount of force required to move a load. The investigations did not focus on the idea that a lever may also reduce the required distance, though this would also be considered a mechanical advantage. In Lever Experiment A, the position of the load stayed constant and the students changed the position of the effort. In Lever Experiment B, the position of the effort stayed constant and the students changed the position of the load. In both investigations, as students manipulated the positions of the effort and load, they recorded the amount of effort required to move the load.

To help students make sense of and share the results from their lever investigations, we developed the student sheet in Figure 2. Specifically, we asked students to write an argument that answers the question: Does a lever make work easier? The student sheet includes writing prompts with *claim, evidence,* and *reasoning* to remind the fifth graders that they need to include these three components when they write a scientific argument. Students needed help learning how to apply the framework to different science ideas (e.g., biodiversity vs. simple machines). Consequently, we included in the writing prompts descriptions of what we were looking for in this specific investigation. For example, under Evidence the student sheet states, "Provide scientific data to support your claim. *Use evidence from your investigation including the position of the fulcrum and the amount of force required to lift the load.*" The first sentence provides a general definition of *evidence*. The portion that is in italics specifies what students should be using as data from their specific lever investigations. Including both the general and investigation-specific support in the writing prompts helped the fifth graders write the strongest scientific arguments by both reminding them of the framework and helping them see how to apply it to the specific investigation.

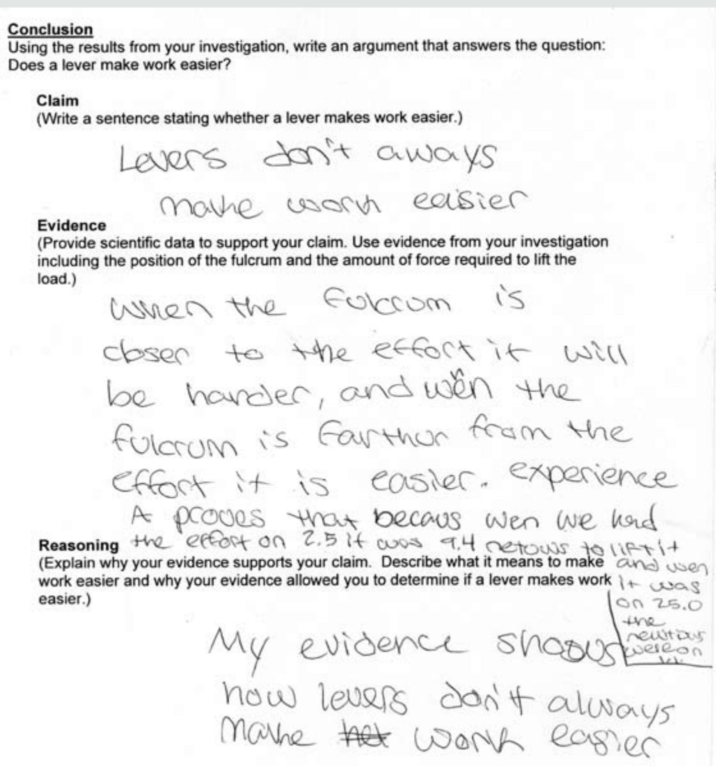
Using Rubrics

We developed a rubric to help us identify the strengths and weaknesses in the fifth graders' writing about the lever investigations (see NSTA Connection). For this specific example, we used the rubric to analyze the student writing to inform future instruction. In other lessons, Mr. Martin provided similar rubrics to his students to support them in evaluating their own writing and to help them revise their writing to provide stronger justifications for their claims. We used the claim, evidence, and reasoning framework to develop the three categories of the rubric and the content from the two lever investigations to develop the levels for each category (McNeill and Krajcik 2008a).

Using this rubric to examine Antonio's writing (Figure 2) helped us identify the strengths and weaknesses in the writing. Antonio provided the correct claim that a lever can make work feel easier but that it depends, so he received a 2 (on a scale of 0–2) for his claim. In terms of his evidence, he provided general statements about what occurred in his investigation, but he did not provide specific data or numbers. Consequently, he received a 1 (on a scale of 0–3) for evidence. This helped us understand that although he knew evidence was "Data from Experiment A or B," Antonio did not understand that he should use specific numbers. For reasoning we gave him a 2 (on a scale of 0–3)for providing a generalization about levers stating, "The position of the effort and load on the lever change the amount of energy needed to lift the lever," which articulates why he came up with the claim that it depends. Yet he did not talk about the idea of "work," which we had specifically included in the question and prompt to encourage students to talk about this scientific idea. Few students in the class actually discussed the idea of work, which suggested to us that they needed more support around including this science idea in their writing. Figure 3 includes an example from another student in the class, Hannah, who has different strengths and weaknesses. She also made a correct claim, but the evidence and reasoning she provides are different. We gave her a 3 for evidence, because she did include specific data (e.g., when we had the effort on 2.5 it was 9.4 N) to support her claim. We only gave her a 1 for reasoning, because she did not provide any generalization about levers or bring in the science idea of work.

Figure 3.

Hannah's written scientific argument.



Conclusion
Using the results from your investigation, write an argument that answers the question: Does a lever make work easier?

Claim
(Write a sentence stating whether a lever makes work easier.)

Levers don't aways make work easier

Evidence
(Provide scientific data to support your claim. Use evidence from your investigation including the position of the fulcrum and the amount of force required to lift the load.)

when the fulcrum is closer to the effort it will be harder, and wen the fulcrum is farthur from the effort it is easier. experience A proves that becaus wen we had the effort on 2.5 it was 9.4 netows to lift it and wen it was on 25.0 the newtons were on ...

Reasoning
(Explain why your evidence supports your claim. Describe what it means to make work easier and why your evidence allowed you to determine if a lever makes work easier.)

My evidence shows how levers don't always make ~~the~~ work easier

The examples of student writing from these two students illustrate the challenges some fifth-grade students had with writing scientific arguments during the middle of the school year. Initially, introducing the framework helped the students be better able to provide a claim that specifically addressed the question and included some justification for why they came up with the claim. Yet they continued to struggle with including specific data as evidence to support their claim and providing reasoning to explain why their evidence supported their claim. Using rubrics helped us identify these challenges, provide students with feedback, and modify instruction to meet their needs. For example, based on the student challenges using evidence during the lever investigations, Mr. Martin facilitated class discussions during which students shared their evidence and had peers agree or challenge the quality of the evidence. This led to the class discussing and students recognizing the importance of including specific data (measurements) and specific vocabulary *(fulcrum, load, effort)* from their investigation in their evidence to support their claim.

Providing Support Over Time

Helping students develop strong scientific arguments during discussion and in writing takes time. After the lever investigation, we continued to provide students with writing prompts on their investigation sheets and Mr. Martin included a variety of teaching strategies in his instruction. He used instructional strategies such as modeling and critiquing samples of writing, connecting to everyday examples, and providing students with feedback (McNeill and Krajcik 2008b).

Reasoning was the most challenging component for his students to grasp. One strategy we used to help students understand what counts as good reasoning was to discuss examples of both strong and weak reasoning statements. For example, Figure 4 illustrates a multiple-choice task in which students had to select which reasoning statement was the strongest for an investigation focused on the question "Does friction affect the distance a car travels?"

Over the course of the school year, Mr. Martin provided his students with a variety of different supports. His fifth graders became better able to make sense of their data and appropriately share the results of their inquiry investigations in which they justified the claims they made with evidence and reasoning. ■

Figure 4.

Does friction affect the distance a car travels?

Circle **ONE** of the following.

A. The data showed us that the car traveled the farthest distance on linoleum, a medium distance on sandpaper, and the shortest distance on the rug. That is why my evidence supports my claim.

B. Friction is a force that resists motion. The rug had the roughest surface so it had the most friction. The linoleum was smooth so it had the least friction. So the greater the friction, the shorter the distance the car will travel.

C. We had fun doing this experiment in class. The data showed that the greater the friction, the shorter the distance a car travels. All of the groups got the same results so that is how we know it is true.

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NSTA Connection

Download the rubric at *www.nsta.org/SC1104*.

Connecting to the Standards

This article relates to the following *National Science Education Standards* (NRC 1996):

Content Standards

Grades K–8

Standard A: Science as Inquiry

- Abilities necessary to do science inquiry
- Understanding about science inquiry

Standard B: Physical Science

- Motions and forces

National Research Council (NRC). 1996. *National science education standards.* Washington, DC: National Academies Press.