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.

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 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.

Mr. Martin then asked Clara to provide 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
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 an object. Specifically, 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.

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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References


