

Disagreeing Like Scientists

Activities from a light energy unit teach students that even scientists have discrepancies in data

By Suzanna Loper and Josey Baker

Students often assume there is one right answer, whether it comes from the textbook, the teacher, or the “smart kid.” But when students are investigating and collecting data about the same topic, they often get different results, and these discrepancies in data are perfectly normal. Scientists may also get different results, even when they do similar investigations. Instead of treating variation in results as a mistake, it can be used as an opportunity to support students in understanding the nature of science, and how scientists disagree productively and resolve discrepancies. In this article, we present a sequence of activities from *Light Energy*, a *Seeds of Science/Roots of Reading*® curriculum about light for third and fourth graders, which supports students in learning to disagree like scientists. This sequence of activities helps students to discuss reasons for the discrepancies in their data, use the language of argumentation in their classroom discourse, and get a more accurate picture of science as a way of understanding the world, rather than a collection of right answers (Driver, Newton, and Osborne 2000).

Modeling Productive Disagreement

Students benefit from models of how scientists and other people can disagree productively. This modeling can come from the teacher, or it can come from a book or magazine article that provides examples of how scientists disagree. In our sequence, students begin by reading a book, *Why Do Scientists Disagree?* (Cervetti 2009). This book describes an historical account of how Galileo made observations of the Moon that led him to disagree with other scientists about what the Moon was made of. In parallel, the book describes how modern scientists also disagree, and why this is important and beneficial for the scientific community. After reading, the class records some things they have learned about what scientists do on an ongoing chart called *What Scientists Do* (Figure 1).

Figure 1
“What Scientists Do” chart.

Predictions about what scientists do	What scientists do	How we were like scientists
<ul style="list-style-type: none">• Find answers• Work in labs• Invent things• Know about light• Mix things together	<ul style="list-style-type: none">• Often work in groups• Ask questions• Read other scientists’ work• When they disagree, they look for more evidence• Support claims with evidence	<ul style="list-style-type: none">• Worked in groups• Collected data• Used evidence when we disagreed• Read books by other scientists

The teacher focuses students on how important it is for scientists to disagree, and how scientists use evidence to resolve disagreements. She points out that students will likely disagree in their own investigations and that to learn from one another they should discuss the reasons why they disagree.

Language of Argumentation

Throughout this sequence of activities, the teacher models and promotes language of argumentation. The following sentence starters help students adopt the language of productive disagreement:

- What do you think?
- What is your claim?
- Why do you think that?
- What is your evidence?
- My claim is...
- My evidence is....
- I agree because...
- I disagree because...

The teacher uses these phrases frequently and prompts students to use them. Gradually these language patterns, and the thinking that accompanies them, become a regular part of the classroom discourse.

Collecting Data on Light Energy

Reading about how scientists disagree sets the stage for the students' investigations. In the *Light Energy* unit, students are learning about how light interacts with different materials. Students work with a partner to investigate a collection of different materials: different colors of felt, wax paper, clear plastic, wood, and aluminum foil. First, they investigate which of these materials transmit light, using a flashlight and a 'light detector'—a piece of glossy white cardboard. Students test each material by holding the white cardboard behind the material and shining the flashlight at the material. They observe whether the material allows light to pass through it and strike the white cardboard. They record their findings in their investigation notebooks. Because of variation in conditions and interpretations, students throughout the class often collect contradictory data.

Debrief Discussion Routine

Next, the teacher introduces a discourse routine called the Debrief Discussion. A discourse routine is simply a repeated structure or sequence of steps that supports students in "talking science" to each other (e.g., Think-Pair-Share) Using a routine helps both students and teacher become familiar with a process, which makes it easier to focus on the content of the discussion. Our curriculum uses a number of different routines to support student discourse in different contexts.

The Debrief Discussion is a routine to help students share data from an investigation, and is most useful in investigations where students are likely to have varying results. The routine helps students share and summarize their results without labeling them as right or wrong. At this early stage in the sequence of investigations, the teacher is encouraged to maintain, rather than discourage, disagreements. By not suppressing disagreements too soon, the teacher allows the

students to focus on describing their evidence. Disagreements will be resolved later, once students have gathered additional evidence.

The teacher uses a chart or transparency to record a summary of students' results (Figure 2). For each material, they record whether it transmits light. There is variation in how much light students thought was transmitted, and for some materials, students disagree on whether light was transmitted at all. In these cases the teacher records *not sure*. She engages in a dialogue similar to the following:

“Milena, what did you and your partner observe when you tested white felt?” (Teacher)

“A little light went through.” (Milena)

“It transmitted a small amount of light?” (Teacher)

“Yes.” (Milena)

(The teacher circles small amount on the transparency)

“What was your evidence that it transmitted a small amount of light?” (Teacher)

“We could see little tiny spots of light on the light detector.” (Milena)

(The teacher records the evidence)

“Milena and Liam found that the white felt transmitted a small amount of light. Their evidence for this was that they saw tiny spots of light on the light detector. Raise your hand if you agree with them that the white felt transmitted a small amount of light.”

(Teacher)

(A number of students raise their hands.)

“Who observed something different from what Milena and Liam observed? Felix and Aidan?” (Teacher)

“We observed none.” (Felix)

“No light was transmitted?” (Teacher)

“That’s right. Our evidence was we didn’t see any light on the light detector.” (Felix)

(The teacher circles none on the transparency, and notes the evidence)

“Who observed something similar to what Felix and Aidan observed?” (Teacher)

(A few students raise their hands)

“Did anyone observe anything different from either of these pairs?” (Teacher)

(No hands)

“OK, let’s discuss what we observed for the wax paper...” (Teacher)

If students comment that other groups are “wrong”, the teacher can remind them that right now, she is recording evidence from each group, even if the groups don’t all agree on what they observed.

After recording the range of the class’ observations, the teacher engages the students in a brief discussion of why different pairs might have observed different things. Students brainstorm a number of variables that may have affected the results, such as how different students held the flashlight or whether they were sitting in a lighter or darker part of the room. The teacher reminds the students that when scientists in the scientific community disagree, they continue to discuss ideas and try to find more evidence. She explains that it’s common for scientists to redo an investigation and observe something different the next time, and that this process might lead them to make a different claim about what’s happening. She explains that it’s fine if new observations cause them to change their minds. They will need to observe closely and think carefully.

Figure 2

Pointers for teaching students how to disagree like scientists:

- Introduce the idea that productive disagreement is an important part of science.
- Provide students with an opportunity to make observations and/or collect data.
- Have students share data and summarize, without evaluating.
- Discuss possible reasons for differences.
- Think of and enact ways to gather more data to resolve differences.
- Repeat routine regularly so that students become familiar with it.

Resolving Students' Disagreements

Allowing for disagreements is important, but resolving them is important as well. Real scientists try to reconcile their results or at least understand why they are different. In another session, the class returns to the summary chart and works to resolve disagreements and draw conclusions about which materials transmit light. The class discusses how to resolve disagreements (for example, by controlling variables that might have affected their results), and conducts tests in which all students can observe what happens. At this point, the teacher tests each material for transmission in front of the class by shining a flashlight through it so all students can see the results at the same time, which makes it possible for the class to come to consensus about what they are observing. Retesting the materials together helps students reach agreement about a set of data without singling out anyone as being right or wrong. The teacher's goal is to create a nonjudgmental, inquiry-based atmosphere in the classroom that encourages students to actively engage in this type of evidence-based discussion.

Conducting Student Assessment

The idea that scientists use evidence to resolve disagreements is an important part of the nature of science. In our unit we assess nature of science ideas both formatively and in a summative way. Monitoring classroom language is one way to assess how students are acquiring the practices of disagreeing productively and using evidence to support their disagreements. We also assess these ideas with writing prompts and in end-of-unit multiple-choice assessments (Figure 3).

Repeating the Routine

As the class repeats the Debrief Discussion routine, the process of sharing data and discussing disagreements becomes easier and more familiar for both the teacher and the students. The students continue to investigate different light interactions, using flashlights and materials to investigate blocking and reflection. As before, the teacher uses the Debrief Discussion routine to collect and represent the range of student results, and the class then resolves disagreements. Through repeated use of this routine, students also gain a deeper understanding of discourse as a practice of science.

In Your Classroom

The Debrief Discussion routine can be used in any situation in which students are collecting data and are likely to have variation in their results. For example, whether students are classifying organisms into groups, collecting weather data, determining the characteristics of objects or substances, or investigating what happens when different materials are mixed together, students are likely to reach varied conclusions. This variety can be an opportunity rather than a problem.

Regardless of the content of their discussions, by engaging in this routine students can reach a greater understanding of both the science content and the benefits and authenticity of productive argumentation.

The following is a summary of the important points to include when teaching students how to disagree like scientists:

- Introduce the idea that productive disagreement is an important part of science.
- Provide students with an opportunity to make observations and/or collect data.
- Have students share data and summarize, without evaluating.
- Discuss possible reasons for differences.
- Think of and enact ways to gather more data to resolve differences.
- Repeat routine regularly so that students become familiar with it.

Figure 3

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

Science Content Standards

Grades K-4 and 5-8

Standard A: Science as Inquiry

- Understanding about scientific inquiry

Standard G: History and Nature of Science

- Science as a human endeavor
- Nature of science

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