Agree/Disagree T-charts

Supporting young students in scientific argumentation and modeling

By Soo-Yean Shim, Jessica Thompson, Jennifer Richards, and Kitten Vaa

How can teachers support young learners in emulating the work of scientists in classrooms? Scientists become curious about the natural world, ask questions about puzzling phenomena, and seek to understand and explain the phenomena by developing scientific models and arguments using evidence (Berland and Reiser 2009; Windschitl, Thompson, and Braaten 2008). The *Next Generation Science Standards* (*NGSS*) and the guiding *Framework* invite students to engage in practices of *scientific argumentation* and *modeling* through which they can collaborate as young scientists and develop understandings of disciplinary core ideas and crosscutting concepts (NGSS Lead States 2013; NRC 2012; Schwarz, Passmore, and Reiser 2016).

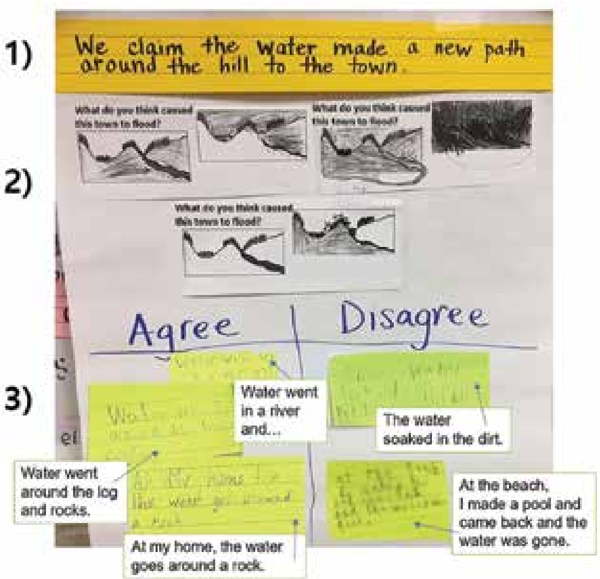
In this article, we share instructional tools and practices developed in a second-grade classroom that enabled students to build explanations through argumentation and modeling over the course of an instructional unit. While we narrate how the unit unfolded and unpack strategies that supported students' engagement in these practices, we want to draw particular attention to an important tool—the Agree/Disagree T-chart (Figure 1)—that grounded class conversations over time. The Agree/Disagree T-chart can support students in

- generating and refining claims about a phenomenon;
- rallying evidence from different unit activities;
- understanding how arguments and models co-develop over time, as new evidence is integrated; and
- making their reasoning public and developing a community that values learning together.

In what follows, we describe how Ms. V, a second-grade teacher who helped develop the Agree/Disagree T-chart tool and instructional unit, used the T-charts and other tools/strategies to support students' argumentation and modeling in the beginning, middle, and end phases of the unit. The unit was taught over the course of three months with two to three 45-minute science lessons per week.

FIGURE 1

An example of an Agree/Disagree T-chart with a claim about what caused a town to flood.



While the unit was mostly taught during time allotted for science, some reading and writing activities were incorporated into literacy lessons when the activities could support multiple standards across disciplines.

Constructing T-Charts

Identifying claims from students' initial models about a puzzling phenomenon. To begin the unit, Ms. V introduced the puzzling and historic phenomenon: Why did a particular town next to a mountain flood after a dam was built on the

PHOTOS COURTESY OF THE AUTHORS

Students build a dam.

FIGURE 2

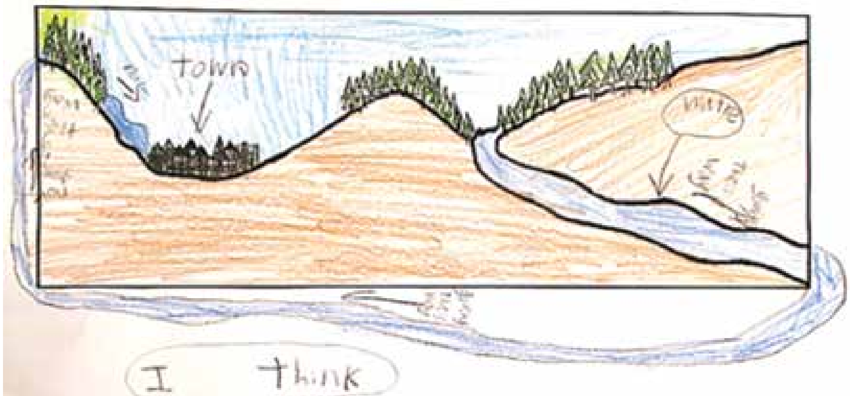
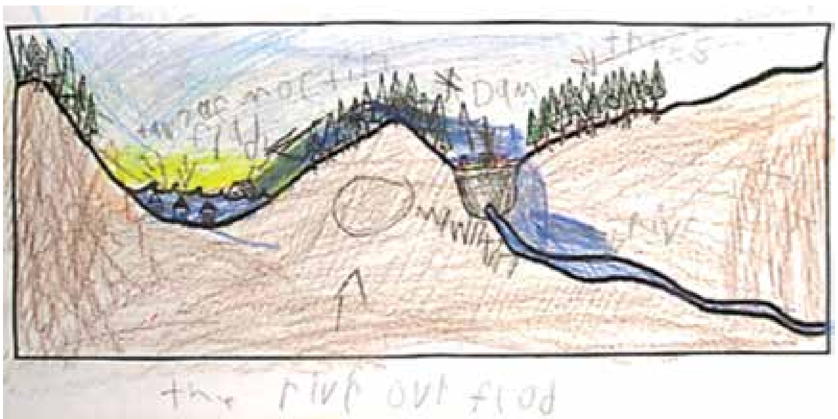
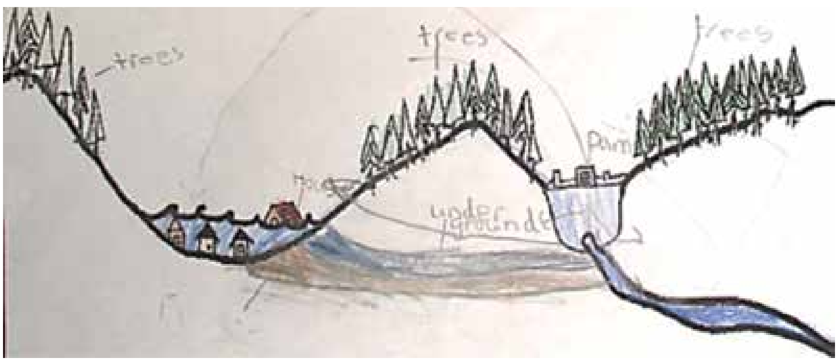
Examples of dams and landscapes that students built.

opposite side of the mountain? Ms. V encouraged her second graders to share their initial ideas about flooding in general, using their personal experiences about the time when their classroom flooded after a heavy rain and about how puddles form on the playground.

Next, Ms. V partnered students and invited them to create initial models. She asked students to draw and write down their thinking about how and why the town flooded, using model templates that included outlines of the town, mountains, and a river before and after the dam was built (the template is pictured in the student work in Table 1). When forming each pair, Ms. V tried to match students who could support each other in co-thinking and expressing ideas, considering their strengths and challenges. For

TABLE 1

Claims identified from students' initial models and examples of models.

Identified claims	Examples of student models
The water made a new path around the hill to the town.	
The water filled up behind the dam and went down to the town.	
The water went through the mountain to the town.	

example, Ms. V intentionally paired two quiet students so that they could have more opportunities to talk and share their ideas during their partner work.

After school, Ms. V looked across students' models to see if students proposed any common ideas. She identified three main ideas that were shared by multiple students and represented different claims about what caused the town to flood. Table 1 shows the three claims and connected examples of student models.

The three claims in Table 1 foregrounded different scientific mechanisms that connected to core ideas targeted in the unit and could be further explored through class activities. The first claim (water made a new path around the hill to the town) invited consideration of processes of erosion and conditions that can promote or slow down such processes (NGSS 2-ESS1, 2). The second claim (water filled up behind the dam) could encourage students to ask questions and analyze data about the amount of rain that year and relative rates of the dam filling up versus releasing water (NGSS 2-ESS2). The last claim (water went through the mountain) connected to important ideas about properties of Earth materials, permeability, and absorption (NGSS 2-PS1).

Making Agree/Disagree T-charts and matching claims with models. Ms. V made three Agree/Disagree T-charts, one for each identified claim. Figure 1 shows an example of a T-chart with a claim at the top, models exemplifying the claim, and the "Agree/Disagree" columns. The following excerpt shows how Ms. V introduced the three claims and invited students to think about the claims:

Ms. V: Yesterday, you shared your initial ideas of what you think might be happening that's causing the flooding of the town. From your models, I could see three claims about how and why the town flooded. Now I want to share the claims with you, and I want you to think about whether you would like to make any changes to the claims or if you want to add any new claims.

After introducing the claims, Ms. V asked students if they agreed with the placement of their models on the T-

FIGURE 3

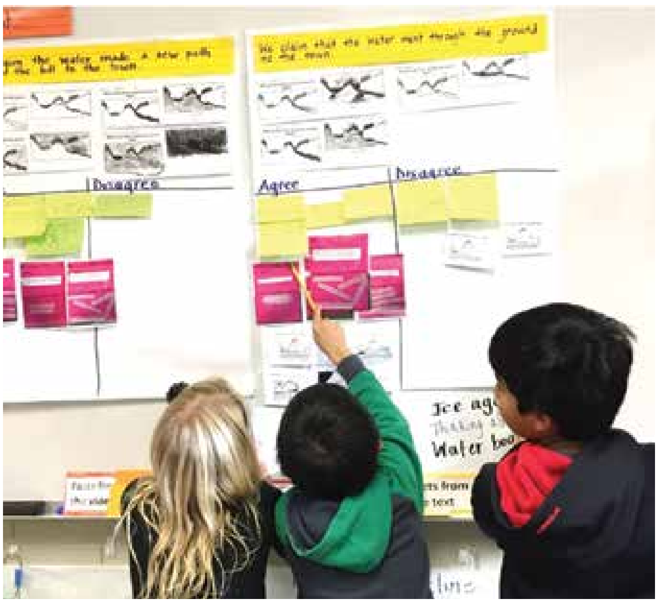
Investigation setup: How different Earth materials affect water flow.

charts. Some students asked to move their models to other T-charts or to make copies of their models and put them on more than one T-chart. The discussion enabled students to clarify their ideas and see connections between their initial models and class-level claims about how and why the town flooded. (Tip: Ms. V initially chose to place student models on the T-charts, anticipating that connecting models with claims might be difficult for students at first; however, based on how active the students were in adjusting the placement of their models, we think it would also be productive to have students place their own models on the T-charts.)

Inviting students to agree or disagree with claims based on personal experiences. Students were then asked to draw or write experiences they had related to water movement or flooding on sticky notes. When students shared what they drew or wrote with the class, the class discussed where the sticky note belonged on the T-charts —whether it agreed with (supported) or disagreed with (refuted) any of the claims. (Tip: When students do this activity for the first time, you may want to consider working on one claim at a time to reduce the cognitive load.) The exchange that follows gives a glimpse of what this conversation sounded like among students and how Ms. V framed the task. In the conversation, a student was sharing her personal experience that she had on the playground during recess that day:

Amelia: Eddie and I were using those tools and pushed the water off the concrete into the dirt. But instead of making a big pile of water right there, it actually soaked inside the soil.

Ms. V: I want everyone to think about "Where does this idea go [on the T-charts]?" Whether that personal experience supports or maybe doesn't support one of these claims. Which one would it be?



Students decide whether they agree or disagree with claims.

FIGURE 4

Activity results poster.

The first column shows different earth materials that were investigated. The second column lists how long it took for the same amount of water to go through each material. Pink sticky notes in the third column include students' observations. Orange sticky notes in the last column include some ideas from readings that could help explain why the observed phenomena happened.

Billy: I think that should go right here (pointing at the "disagree" side of the claim about water making a new path and going around the mountain).

Ms. V: Can you explain why?

Billy: Well, it [the claim] says the water stays top on the ground, not into, under the ground.

Eddie: Yeah, but … wouldn't that also support that one (pointing at the "agree" side of another claim about water going through the mountain)? It went into the ground. It says that right there.

Such conversations helped the class populate the T-charts with evidence from personal experience that supported or refuted their claims and validated students' experiences as meaningful evidence.

FIGURE 5

A conditional argument written by a student using the "If _____, then _____ because _______." sentence stem.

Making Sense of Activities

As the class got further into the unit, they engaged in activities (investigations, readings, watching videos, and so on) that provided additional evidence for students to consider in relation to the flooding town. Ms. V continued to support students' reasoning with evidence about specific activities and through synthesizing across activities.

For example, in a two-day lesson, students watched a video about dams and learned about the role of dams through a read-aloud (see the Curriculum Guide under Internet Resources). Then, groups of four students built a landscape on a tray using three "Earth materials" (pebbles, sand, and soil) and observed how water flowed through the landscape. *Safety note: Students should wear safety glasses when using the Earth materials and manipulating water.* Ms. V prepared 10 cups of each Earth material (1 cup = 16 oz./473 mL) for the whole class and students used all three kinds of materials to build landscapes. To make the water flow, in each group, a student poured water from a kettle into a plastic cup that had a hole on the side, and another student held the cup and made the water come out from the hole to one side of the tray on which the landscape was built. The tray had a hole on the opposite side so that the water could flow through the landscape to the hole. Another student held a basket at the end of the tray to collect water that came out from the hole. When each group made the water flow, the whole class gathered around the group to observe how water flowed through the landscape. Students used about a half cup of water for each trial and repeated the process to make further observations.

Students then designed a dam (with a straw, clay, and the Earth materials), predicted how their dam would affect water flow, and tested the dam and observed the change in water flow and impact on the landscape. Figure 2 (p. 40) shows some examples of dams and landscapes that students designed and built. Throughout the activity, students recorded their observations and engaged in small-group and whole-class discussions to generate claims and reasoning in response to the following questions: How does water flow when a dam is added? Why? Examples of student responses included: "The water flows through the sand because sand is not solid" *and* "Water flowed through the dam because the sand soaked it up and pushed it out."

As students engaged in various activities, Ms. V regularly asked them to connect what they were observing to bigger explanatory ideas and to their claims about the dam and how the town flooded. After the dam investigation, students revisited the T-charts and engaged in a similar process as they did with their personal experiences, discussing whether their activity-level claims and observational evidence about how dams changed the water flow and landscapes should go in the "Agree" or "Disagree" column on a given T-chart. For example, a pair of students concluded

FIGURE 6

Color-coding for different sources of evidence (types of unit activities).

Ms. V used a color-coded scheme to call out different sources of evidence—this was important for setting up synthesis opportunities toward the end of the unit, when students were evaluating the strength of claims in part by whether a claim was supported by multiple, converging sources of evidence. Personal experiences and investigations were primary sources, while others (facts from videos/texts, other people's experiences and investigations) were secondary sources.

and wrote, "The water flows around because the water can't go one way because it would not all fit together." Ms. V asked the students to write down their observations that could support the conclusion. The students wrote that they observed that the water went around the dam that they built. In the whole-class discussion to revisit the T-charts, Ms. V asked the students where this conclusion would fit in the T-charts, and the students said that it would agree with the claim about water going around the mountain to the town. Another pair of students concluded and wrote, "The water flows through the sand," and put the conclusion in the "Agree" column of the T-chart that had the claim about water going through the mountain to the town.

In another two-day lesson, students read about the history of the mountain next to the town and learned that it was initially formed by the melting of glaciers, and as such was composed of rocks, pebbles, sand, and soil. Students conducted an investigation to test how different Earth materials affect water flow by putting the materials in funnels and pouring water on top. Figure 3 (p. 42) shows how this activity was set up. Ms. V prepared six clear cups and put funnels with filter papers on them. In each funnel, she put the same volume of (1) pebbles, (2) sand, (3) soil, (4) clay, and (5) the mixture of pebbles, sand, and soil. She put nothing in the last funnel. Then, she poured the same amount of water into each funnel one by one and asked students to measure how long it took for the water to go through each funnel and write down their observations. Figure 4 (p. 43) shows the poster made from this activity.

From the investigation, students saw a pattern—that water flowed more easily through Earth materials that had bigger particles and bigger holes between particles. Ms. V supported students in connecting this insight to the phenomenon by asking them to write conditional arguments that would hold true for the mountain: "If the mountain—glacial moraine— was mostly made of (one or two kinds of Earth materials), then (how the water would flow) because (evidence and reasoning from the investigation)." See Figure 5 for a student example. After the activity, students revisited the T-charts and discussed whether their conditional arguments would support or refute any of the unit-level claims. Throughout the unit, Ms. V made frequent use of sentence stems like "If ____, then ____ because ______." or "I know this because ______." to press students to support ideas with evidence and reasoning.

Taking a Stand

At the end of the unit, the class considered the Agree/Disagree T-charts with evidence from across the unit. Synthesizing the information on the T-charts was challenging, and Ms. V tried several options for supporting students in doing so. What turned out to be key was engaging students

Students work on their dam.

in explicit discussion of what counted as a well-supported claim. She then asked: "What should we look for on the T-charts?" Ideas such as having the most sticky notes under the "Agree" column, having different colors of sticky notes under the "Agree" column (showing that different sources of evidence supported the claim), and having few or no sticky notes under the "Disagree" column were all relevant considerations. Near the end of the unit, students used one or more of these rationales when they were asked to "take a stand" on which claim was best supported. The unit ended with a summative assessment in which students used the Agree/Disagree T-charts to revise their initial scientific models and write evidence-based explanations. They were encouraged to add evidence using the sentence stem of "I know this because in the ______ activity I learned that ______."

FIGURE 7

A pair of students' final models about how and why the town flooded.

Students' developing models and written explanations provided a natural way to assess learning throughout the unit. For summative assessment purposes, Ms. V closely compared students' final models and written explanations with their initial models to see how they developed their explanations about the flooding of the town using evidence from class activities. She used a rubric to assess students' models and explanations (see NSTA Connection). The rubric included two dimensions: depth of scientific explanation and use of evidence. For depth of explanation, Ms. V examined whether students included claims, core ideas, and cohesive reasoning to explain *how and why* the construction of the dam caused the town to flood. She found that most of the students claimed that the water from the dam went through the mountain or around the mountain to the town and drew the flow of water through specific Earth materials by "zooming in" on the mountain or the ground. For use of evidence, Ms. V focused on how students made connections between evidence from multiple sources and their claims to support their explanations (Figure 6, p. 45). She found that most of the students described or used more than two pieces of evidence that they drew from the Agree/Disagree T-charts, their science notebooks, charts summarizing class activities, and their own observations and experiences.

Figure 7 shows a final model and explanation from a pair of students. Ms. V rated the model/explanation as "Meeting" for depth of explanation as students claimed that the water from the dam went through the mountain to the town and explained the composition of and flow through the glacial moraine. The model/explanation was rated "Approaching" for use of evidence because students described what they learned from unit activities but did not explain how the learning supported their claim or explanation.

Summary

The examples and artifacts from Ms. V's classroom demonstrate how young students, when intentionally supported, can engage in scientific practices of argumentation and modeling in meaningful and evidence-based ways. Throughout the unit, the Agree/Disagree T-charts provided a critical thru-line to connect the practices and supported students in developing their understandings and explanations of the phenomenon. Second graders were able to construct models of a puzzling phenomenon based on their own ideas and experiences, revise these models based on learning from classmates and unit activities, determine whether a given piece of evidence agreed or disagreed with a claim, reason with multiple forms of evidence, create conditional evidence-based arguments for "what would happen if," and begin considering how to use complex syntheses of evidence to determine how well claims were supported. ●

REFERENCES

Berland, L.K., and B.J. Reiser. 2009. Making sense of argumentation and explanation. *Science Education* 93 (1): 26–55.

National Research Council (NRC). 2012. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academies Press.

NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states*. Washington, DC: National Academies Press. *www.nextgenscience.org/next-generation-science-standards*.

Schwarz, C.V., C. Passmore, and B.J. Reiser. 2016. *Helping students make sense of the world using next generation science and engineering practices*. Arlington, VA: NSTA Press.

Windschitl, M., J. Thompson, and M. Braaten. 2008. Beyond the scientific method: Model-based inquiry as a new paradigm of preference for school science investigations. *Science Education* 92 (5): 941–967.

INTERNET RESOURCES

Integrating Scientific Argumentation and Modeling for K–2 Learners: A set of three videos developed from this unit by the authors and Teaching Channel. *www.teachingchannel.org/blog/2017/05/05/sci-argumentation-modeling-k-2*

2nd grade Earth Systems Curriculum Guide. *https://ambitiousscienceteaching.org/2nd-grade-earth-systems*

Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013)

- The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities.
- The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectation listed below.

Standards

2-PS1. Structure and Properties of Matter

www.nextgenscience.org/topic-arrangement/2structure-and-properties-matter

Performance Expectation

2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

DIMENSIONS	CLASSROOM CONNECTIONS
Science and Engineering Practices	
Engaging in Argument From Evidence	Students used the Agree/Disagree T-charts to develop and refine their arguments.
Developing and Using Models	Students constructed models to explain the flooding of the town and revised their models as they developed arguments concerning land and water movement.
Disciplinary Core Ideas	
PS1.A: Structure and Properties of Matter Matter can be described and classified by its observable properties.	Students gathered evidence about observable properties of Earth materials and reasoned how different properties might affect water flowing through the mountain.
Crosscutting Concepts	
Patterns	Students explained slow and rapid changes based on observed patterns.

Soo-Yean Shim *(sys7829@uw.edu)* is a doctoral student, **Jessica Thompson** *(jjthomps@uw.edu)* is an associate professor, and **Jennifer Richards** *(jrich14@uw.edu)* is a research scientist, all in the College of Education at the University of Washington in Seattle, Washington. **Kitten Vaa** *(kitten.vaa@nlcinc.com)* is a second-grade teacher at Brighton School in Mountlake Terrace, Washington.