Imagine it is a typical day in a typical middle school science classroom. Students are working in pairs on a series of problems involving Punnett squares. There is a low buzz of activity in the air. Most students are on task, discussing the problems in between talk of weekend plans and the music they think is awesome. The teacher walks around checking work and monitoring behavior. And then, as often happens, a student raises a hand and asks a typical question: “My answer is different than my partner’s answer; which one is correct?”

Teachers are caring people. We like helping students learn. We like sharing our love of science with students, and we get excited when a question is asked. As such, a typical teacher response is often to point to the correct answer and explain why the answer is correct.

In another classroom, a student asks the same question, but the response from this teacher is different. In this classroom, students are expected to talk about what they think the answer is, share why they think their answer is correct, and attempt to come to a consensus on the answer before they seek mediation from their teacher. Instead of giving the student the correct answer, this teacher reinforces student-to-student collaboration by pointing to the directions for the activity and asking that the two students come to a consensus based upon credible information from their textbook, class notes, labs, or other sources.
In most classrooms, the teacher serves as giver of information and students are recipients. But this typical practice in science classrooms does not match typical science practices. Indeed, Osborne notes that “argument and debate are common in science, yet they are virtually absent from science education (2010, p. 463). Conversely, the teacher in the second scenario facilitates student thinking through orchestrating student-to-student interactions in a climate that promotes collaboration. The expectations are for students to share their thinking about science concepts, use credible evidence to justify their thinking, and reach a consensus.

With the publication of A Framework for K–12 Science Education (NRC 2012) and the Next Generation Science Standards (NGSS) (Achieve Inc. 2013), we see an intentional move in science education toward creating science classrooms where student-to-student collaboration and analysis replace a singular focus on learning “stuff.” However, Schiller and Joseph note that “facilitating equitable classroom discussions is a tricky business, one that requires thought and planning” (2010). Student-to-student collaboration requires that the teacher not only plan for the cognitive demands required to learn science content, but also that the teacher make explicit plans for productive student-to-student dialogue.

The following two classroom examples come from working with nearly 100 middle school mathematics and science teachers across the state of South Carolina for the purpose of transitioning their instructional practices toward student-to-student collaboration.

The examples include the following classroom practices: Student pairs reading a text and participating in a quick activity at the start of class, often called a bell ringer. Teachers in our program, like the teacher in the second scenario, use these strategies to provide time for students to process information through student-to-student collaborations in a safe climate where teachers guide processes to ensure students both succeed in their student-to-student interactions and meet the cognitive demands of the content. Critical components of this process include a focus question to engage student thinking about science content, student-to-student communication, and coming to consensus.

Coming to consensus through text

The first example is a reading activity that takes place in a middle school science classroom that has been arranged so that students work in pairs. The content focus is the Moon’s gravitational effects on Earth, and the teacher prepares students for the reading with an anticipatory focus question designed to provide a purpose for the reading: “A weather reporter on TV said that hurricanes are more dangerous when the Moon is full. Do you agree? Explain your answer.”

Underneath the question, the teacher offers a scaffolded prompt that students may use: “I believe that hurricanes are (more/less) dangerous when the Moon is full because ____.”

After all students write an individual response in their science notebook, the teacher gives them clear directions for partner talk and models appropriate behavior through a variety of methods, such as role play. The purpose of the partner talk at this point is for students to share their current thinking with a peer and allow them time to modify their answers.

Working in pairs, students are identified as Partner A and Partner B. Beginning with Partner A, each student has 30 seconds to share his or her answer and reasoning while the other partner listens without interrupting. The teacher uses a timer that all students can see, prompts Partner A to dialogue with Partner B, prompts students to switch to Partner B, and brings the student-to-student interaction to a timely close.

During the partner talk, the teacher walks around the room monitoring behavior and listening to students as they talk about their thinking.

In most classrooms, the teacher serves as giver of information and students are recipients. But this typical practice in science classrooms does not match typical science practices.
Following the focus question and partner talk, students silently read a brief section of text or other source material. Brevity is essential, as text in science is typically information dense. In the scenario described, the reading is composed of just two paragraphs. With a clear purpose for reading, students interact with the text, searching for clues that will help answer the focus question and, hopefully, resolve any differences they have identified in their initial thinking.

After silent reading, students are asked to reflect on the text by rewriting the initial response they recorded in their science notebook, this time using information from the text to support their answer. Students then engage in partner reading, where they take turns reading one paragraph of the text aloud to their partner. After the partner reading, more time is given for students to modify their answers to the focus question.

Should differences in their responses remain, the teacher may use the “silent debate” strategy. Here, students switch papers, silently read what was written by their partner, and then write a response. The teacher again offers a scaffolded prompt that students may use: “I think that your answer is (correct/wrong) because (cite something from the text).”

Students continue to swap papers and argue through writing and citing points in the text until the pair reach a consensus. During the entire process, the teacher walks around the room to monitor behavior and listen to student-to-student dialogue. Only if pairs remain at an impasse does the teacher mediate their thinking.

**Coming to consensus through demonstration**

Many teachers use short activities called “bell ringers” to begin a class, quick checks during class time, and exit tickets as formative assessments. The following example comes from an eighth-grade science lesson where the teacher used a quick-check question in the middle of a lesson to gauge levels of student understanding of material. The question (Figure 1), which asks students to predict the path of a marble as it exits a circular tube, is based on common misconceptions students have about orbital and circular motion (Hestenes, Wells, and Swackhamer 1992).

As in the above example, the quality of the question used is essential in getting students to think about and argue their current understanding of science concepts. Common content-related misconceptions make excellent staring points for student-to-student collaboration in the science classroom, and there are many resources that a teacher can use as sources for misconceptions. However, the best questions for collaboration come when teachers conduct item analyses on their tests and quizzes to identify relevant misconceptions.

The teacher precedes the demonstration with a think-ink-pair-share (TIPS). Each student reads the question, thinks about what the answer might be, and individually commits to an answer by writing it on paper (this is the I in TIPS, for ink). In pairs, students take turns explaining and listening for a specified time period (depending on the students and question, the teacher may allow 15 to 60 seconds per person). When explaining, students must give an answer and provide their reasoning or evidence for its correctness. When listening, students pay attention to the evidence given and may not interrupt. This dialogue may change students’ thinking, however, consensus is not the goal at this point.

Depending on how widespread the disagreement is between the pairs in the classroom, the teacher may orchestrate broader dialogue by using a pair-square, in which two pairs combine to form a team of four. In round-robin fashion, each student again has a specified time to present his or her answer and argue his or her point. After this structured session, time is given for team members to try to come to a consensus on the answer, though they may not yet be able to do so at this point.

Resuming the TIPS exercise, teams are asked to simultaneously share their answers to keep engagement high and prevent last-second consensus changes.
based on the “vote” of other teams. Teachers in our study have students use whiteboards or “finger voting” (one finger represents A, two fingers represent B, etc.) to identify their consensus response. Teams not reaching consensus may vote as individuals. In one particular classroom, students could not come to a consensus on the path of the marble via dialogue alone. They needed evidence, and they were now ready for it.

At this point, the teacher can effectively mediate their thinking and bring closure to the dialogue on the path of the marble through a purposefully planned simple demonstration. The teacher brings out a length of hollow foam insulation for pipes and a marble. The hollow insulation is placed on a table in the same configuration as in Figure 1.

Before conducting the demonstration, the teacher again gives time and guidance for team dialogue and consensus using similar protocols from earlier in the lesson. The old adage “practice makes perfect” applies to student use of strategies in the classroom and is conducive to a classroom environment where student-to-student dialogue is the norm and student engagement is expected of all.

Although this additional time for dialogue toward consensus may appear to be redundant, it is important to note that moving from a two-dimensional drawing to a physical demonstration requires another level of thinking. During this process, some students change their answer, while others do not.

With a classroom full of students waiting to see what will happen, the teacher releases the ball. The evidence is there for all to see. With the quick check complete, the teacher continues with the lesson as planned, secure in knowing that students now have a better understanding of a science concept.

**Conclusion**

It is important to note that the strategies chosen at each point in and the time frame of the process are dependent on several factors. These teachers explicitly planned each lesson based on its placement within a coherent unit, the type of science content to be learned, and students in their classroom. Time for these processes may be reduced or lengthened depending on the level of student understanding, which the teacher can clearly see and hear. This article provided two examples of student-to-student collaboration and consensus using common classroom strategies. Most any classroom strategy can be modified to include time for student-to-student collaboration and consensus.

When considering a typical day in the middle school science classroom, we may see students working together, but we may also see that “the teacher remains at the pinnacle as the classroom leader during discussions” (Schiller and Joseph 2010, p. 57). In the Framework and NGSS, we see a shift in the role of the teacher and how students learn—they should be engaging in argument from evidence, evaluating, and communicating information. Teachers in our research project cite two roadblocks that prevent them from shifting their lessons toward student-to-student collaboration: time and student behavior.

Osborne states that “students need to be taught the norms of social interaction and to understand that the function of their discussion is to persuade others of the validity of their arguments” (2010, p. 465). In classrooms that promote collaboration, behavior problems are minimized when students engage in productive and civil dialogue with guidance and structure provided by a well-prepared teacher.

In an era when standards and testing drive curri-
Student-to-Student Collaboration and Coming to Consensus

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Many teachers feel they do not have time for student-to-student collaboration. In both of the examples offered, much classroom time was spent adding opportunities for collaboration to promote deeper learning of specific science content. The question teachers often ask is “Do I have time to do this?” The answer, of course, is that a high degree of professional judgment must be used in planning for student-to-student collaboration in the science classroom. Yes, there are times when the pace of instruction is slow and times when it is fast, depending on the content, context, and students in the classroom. Perhaps a better question might be “What would happen to student understanding of science concepts if collaboration were a typical classroom practice?”

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