Scientists ask questions, acquire information from observations, and craft evidence from that information to make sense of the natural world. Engineers build on that sense-making to solve human problems. Teachers use those same processes to make sense of student thinking to move learning forward. The most immediate and vital source of evidence is daily student work.

Effective teachers design supportive, engaging learning environments that surface students’ thinking and provide targeted feedback that they act on to improve their learning. Peers can help too. These processes—the essence of formative assessment—enable students to develop confidence in their learning abilities and to retain new knowledge and skills.

Formative assessment enables students to develop a growth mindset.

[Formative assessment is] “a planned, ongoing process used by all students and teachers during learning and teaching to elicit and use evidence of student learning to improve student understanding of intended disciplinary learning outcomes and support students to become self-directed learners.”

—Council of Chief State School Officers
Like most teachers, I’m happy when my students are engaged. I’m even more pleased when they appear to, “Get it.” However, experience and reflection have taught me not to rush to judgment or to move ahead to the next lesson too quickly.

My fourth graders were just starting to learn about electric circuits. We got out the bulbs, batteries, and wires. Every student was engaged. Lighting a bulb was not an easy challenge for students to accomplish, but they persevered. Some were more successful than others, but after a few warm fingers and other struggles to get the bulbs to light, most were able to accomplish the desired result if only with a flicker of light. The bell rang for recess, but half the class wanted to stay in to find other ways to light the bulbs. Who was I to say “no”?

I had taught the perfect lesson; students were engaged, cooperative, and eager to continue learning more.

After school, I started to think about formative assessment and decided that it was a great time for students to show off what they had learned. Tomorrow I would hand them the picture you see here, and ask them if they think the bulb would light. I was sure that they would all see that the light bulb would fail to light because a single wire was connected between the bulb and the battery in such a way that there was only one contact point on the bulb. Here are a few of the responses I received.
Here is one example of how one teacher, Gloria, harnessed the power of formative assessment to improve her students’ learning.

“I think it will light because when we had to make the light bulb light with one wire, I think this is the way I did it and it worked.”

“I think it won’t light because first the battery has to be turned over. Second, the black bump on the battery has to touch the bottom of the bulb.”

“This bulb will light because the wire is in a circle. Whenever the wire is in a circle, it will light.”

Out of my 34 students, 33 of them gave me answers like those above. None of them was thinking about the importance of the contact points on both components especially the bulb…except for one:

“This picture will work because the wires are touching the D-cell and the light bulb are touching the wires so the light bulb will light…Wait a minute, I don’t think it will work because the wire has to be touching the side of the light bulb.”

[Note: I love this answer because it shows how writing can help students process the problem in a different way and sometimes change their minds about their thinking.]

So much for the perfect lesson! It was time for a next step strategy. I chose to use the critical competitor strategy. The next day in class, I displayed the two pictures you see on the right. I asked the students to look carefully at the pictures, to talk in their groups, and come to consensus about whether each bulb would light. Then we took a class vote. I was surprised when half the class voted for A and half for B, but then a class debate ensued that was so enthusiastic, the best thing that I could do was to stay out of it! As the arguments concluded, students could use what they had learned from their sense-making discussion to test their working knowledge. And everyone clarified their knowledge of “circuit.”

As a result of a quick formative assessment activity, it became clear what students had learned and what they had missed. The next-step strategy (critical competitor with debate) would be the opportunity to work with peers to come to understanding: There have to be two contact points connected on each of the components to ensure a complete pathway for electricity to flow. I shudder to think about the problems we would have had if we had continued on before students established this fundamental understanding of contact points.
Like Gloria, we show up every day to teach—frequently work into the night at home—to improve student learning. We do it to make a difference in lives. It is our work and our passion. Our biggest challenge is that even on the best days there is a gap between what we expect students to learn and what they do in fact learn. That is the situation. It is the nature of what we do.

Teaching is a constant, dynamic mix of joy and frustration. We cannot force or will students to learn, nor can we just tell them what to think. However, to do our job—create an environment for learning and support student success—we need to have access to what students have learned and what they are thinking.

Students show up each day. To learn they must be active, willing participants. They decide how much to engage. Only they can do the learning. They make every new observation and intellectually construct the multitudes of connections, relationships, concepts, and models. They do so individually and during social engagement with others. Their level of interest and their social/emotional response to the tasks asked of them, the environment in which they live and work, and the people with whom they engage, serve as filters through which all learning is mediated.

Equally important, students need to know where their learning is headed, what improvement looks like, and what they can do to enhance and advance their learning. Feedback from teachers and peers can help them achieve the goals of effective learning.

Achieving both teacher and student learning goals yield the process called formative assessment: Both teachers and students use student-generated evidence to move learning forward. In the vignette, the teacher provided multiple opportunities for students to process information to make sense of phenomena—the essence of science—and to reflect, improve, and communicate their learning. The teacher analyzed data from an assessment looking for patterns in student thinking, and planned a next-step strategy as targeted instruction to improve student understanding.

STRIVING FOR EQUITY IN ASSESSMENT

Students arrive in our classrooms with a myriad of disparate economic, social, psychological, and emotional experiences. We have limited control over these out-of-school learning influences. However, we are committed to the idea that students from all cultural and economic backgrounds can and must learn to make sense of the natural world and about how people can act to make the world a better place for all to live. Paying attention to equity in all aspects of instruction, including assessment, and acting to
ensure it, is central. We know that students are wonderfully diverse so acting on equity means creating learning environments and student interactions that are accessible and responsive to that diversity. The work in which we ask students to engage should be culturally and personally interesting and meaningful. We need to build on students’ strengths.

In Gloria’s classroom, students were provided with sufficient time to work with the same materials individually and with a partner, to share ideas in a small collaborative group, and to share group ideas with a class. This builds on strengths and develops students confidence.

**EMBRACING MISTAKES AS PART OF LEARNING—GROWTH MINDSET**

Students arrive in our classroom with a continuum of notions about their capacity to learn. Even at an early age, many have come to believe that they are inherently smart or not—a fixed mindset. It influences whether students will commit to the hard work of learning or will give up in frustration or embarrassment. Alternatively, other students have learned that hard work and learning from error is the key to success. They embrace a growth mindset. In fact, developing new scientific understanding and improving engineering designs depend on a growth mindset—figuring out what is not known, persevering when the answer is not immediately forthcoming, and acting to adjust thinking based on evidence.

Two phrases exemplify the culture shift at the heart of formative assessment: “I haven’t learned it … yet.” And, “I used to think, but now I know…, because ….” For teachers and students, accustomed to typical tests and grades, this shift in how we interact and think about learning takes time and work.

When students perceive personal judgment in response to their work, they learn that the goal of school is to please others. They hear you are worthy because, “You got it, so I am pleased with you.” Or, “I am disappointed in you because you failed to get it!” There are alternative responses that convey, “You didn’t get it yet, but you will” (Camins, 2018).

In Gloria’s classroom, at the end of the next-step strategy and class debate, students could with confidence describe their new understandings about circuits in their science notebooks and explain how their thinking had changed.

We see in our classrooms that science investigations and engineering design challenges have a special appeal for students. They are naturally curious about their observations of events in the natural world—about investigating and explaining phenomena. They find designing things to help people inherently appealing.

That is the work of scientists and engineers. Sense-making—investigating phenomena and explaining how things work—is what science and engineering are all about. And
good explanations, whether from experienced scientists or student scientists, require incremental progress and embracing that some ideas need refinement or major corrections.

Sense-making is a quintessentially human activity. We observe the natural and social worlds in which we live. We make connections among those observations. Without sense-making, everything would be random and bewildering. We develop relationships and concepts that enable us to live in and understand the world. Everyone does it from birth until death.

To help students learn science and engineering we need to use formative assessment to probe and assist their sense-making.

“Making minor learning adjustments as learning progresses is a far better use of time than waiting until the end of large instructional blocks.”

MAKING EFFECTIVE USE OF PRECIOUS TIME

One thing we all know for sure; there is never enough time to do everything we should or want to do. Teachers use encouragement and guidance to help students reflect on and modify their thinking to advance their learning. So efficient, effective time management for formative assessment is critical.

Making minor learning adjustments as learning progresses is a far better use of time than waiting until the end of large instructional blocks.
For some teachers, organizing the classroom around formative assessment reinforces and builds on what they are already doing. It requires small but conscious shifts. For others, it is a big change. For everyone, it requires purposeful planning and choices about what to assess, and how often.

Assessment occupies such a central position in good teaching because we cannot predict what students will learn, no matter how we design our teaching... Students do not learn what we teach. If they did, we would not need to keep gradebooks. We could, instead, simply record what we have taught. (Wiliam, 2017, p 53-54).

FOSS (Full Option Science System® program for grade PK–8) has developed the Reflective Assessment Practice (RAP) during which teachers spend 10 minutes after a lesson sampling student data and determining the next instructional steps. This Reflective Assessment Practice is described in detail in the Assessment Chapter in each FOSS module Investigations Guide.

Of course, knowing what students think and know is only the first step in formative assessment. Influencing how they think about the natural world is the bigger challenge. We have all experienced students...
appearing to understand something one day only to find out the next day or weeks later that they did not grasp the concept after all.

That is why the FOSS instructional design calls upon students to express and reflect on their thinking in multiple and successive ways. Teacher and student attention to notebook entries, response sheets, and I-Check formative assessments keep the learning moving from short- to long-term memory.

Students bring their ideas to making sense of the natural world. Some of their ideas are accurate, some are incomplete, and others are just incorrect. Our job is to help move student understanding along the continuum from naïve to more sophisticated scientific knowledge.

In FOSS, Focus Questions, What to Look For, Science and Engineering Practices, and Crosscutting Concept notes in the Investigations Guide are all positioned to help teachers focus their formative assessment activities. Next Step Strategies (described in detail in the Assessment Chapters) are used in conjunction with I-Check Coding Guides to assist students in reflecting on and adjusting their thinking to move learning forward.

Teachers have found that reflective assessment practice takes time to learn not just for themselves but for students. So, try out a few to ensure some variation. Practice may not make learning perfect, but done thoughtfully, we are certain that you will see improvement.

We were not surprised to find that when teachers focus their attention on formative assessment, targeted on learning goals, student learning can be increased. We were happy to find, however, that a relatively modest investment of time brought such a dramatic improvement in student learning. It was not necessary for teachers to introduce new activities or additional tests into their classroom schedules; instead they used what students were already producing as part of the regular instructional activities, making this assessment technique both informative and manageable (Kennedy, Long, and Camins, 2009).

Through these reflective processes, students get targeted feedback from peers and their teachers to improve their own learning. This is the kind of learning that sticks with students and builds self-confidence. Improving these practices is a great investment of teachers’ and learners’ time.
References


Coming soon: For more support using formative assessment tools, look to the FOSS Professional Learning Series on-line. There you will find videos on the RAP for grades 3-8, next-step strategies, and sense-making.