Chapter 1

An Introduction to 50 More Formative Assessment Classroom Techniques (FACTs)

CLASSROOM SNAPSHOT OF FORMATIVE ASSESSMENT IN PRACTICE

Fourth-grade students are learning about the properties of solids and liquids, building upon what they learned in the primary grades. They are using *Claim Cards* created from the justified list formative assessment probe, "Is It a Solid?" (Keeley et al., 2008), to engage in a productive science discussion about solids and liquids. One of the students claims that flour is a liquid. The teacher uses *Talk Moves* to probe further and elicit other students' thinking about this claim. Several students defend the claim, explaining that liquids take the shape of their container and can be poured. Another student provides further support for the claim by stating that flour is not hard like solids and doesn't have a shape. When the teacher asks if anyone thinks flour is a solid, over half of the class agrees with the claim that flour is a solid, but aren't sure why, and seem puzzled by the liquid explanations shared by their peers. They hold firmly to their claim that flour is a solid, but all they can use to defend their claim is that it is not like water: it is not wet, it doesn't freeze, you can't boil it, and it doesn't evaporate if you leave it in an open container.

As the teacher listens to the students' reasoning, she realizes the stumbling block is that students do not recognize flour, or powders for that matter, as being made up of a collection of very small, solid particles. She realizes she needs to give them a scaffolded experience in examining things that seem to fit their correct conception of a liquid, as taking the shape of its container and able to be poured, but are visibly made up of small, solid pieces. She decides to start with a collection of larger parts—marbles in a jar. Her students can see how the marbles fill the jar and can be poured out of the jar. They agree that the individual marbles are solid and that when there is a collection of marbles, they seem to fill and take the shape of a container and can be poured like a liquid.

After using the marbles as an anchoring example, the teacher then asks students to observe salt and discuss how salt in a jar is similar to marbles in a jar. The students examine the salt crystals and agree that each small, individual salt crystal is a solid. The teacher uses *Talk Moves* to probe further and assess how students are relating the salt to the marbles and distinguishing both from liquids such as water. She then poses the flour question again and listens for evidence of students' changing their initial claim based on new evidence. The class agrees on the consensus claim that flour is a solid and is able to explain their reasoning, using the marble and salt examples. She then asks them for examples of other powders or collections of very, small solid parts. Finally, she asks them to explain how liquids, such as water, are different from solids. The teacher concludes the lesson by referring students to the *Learning Intention* that was posted at the start of the day's lesson: "Understand the difference between solids and liquids." She uses the *Thumbs Up, Down, and Sideways* technique—a self-assessment for students to indicate the extent to which they feel they've met the three *Success Indicators* listed at the beginning of the lesson—as evidence of meeting the *Learning Intention*: (1) I can describe the properties of a solid, (2) I can describe the properties of a liquid, and (3) I can distinguish between solids and liquids. The teacher decides to add a fourth *Success Indicator,* based on the scaffolded part of the lesson that addressed powders: (4) I can use a model to explain why a powder is a solid. As a reflection at the end of the lesson, she asks her students to do a quick write on how well they think they met *Success Indicator* 4 and to draw a picture of their model.

This brief classroom snapshot is an example of the inextricable link between formative assessment, good instruction, and learning. Formative assessment is frequently referred to as assessment *for* learning, rather than assessment *of* learning, which is summative assessment. The preposition makes a difference as formative assessment's primary purpose is to inform instructional decisions and simultaneously support learning through continuous feedback to the learner. However, a third preposition can also be added: assessment *as* learning. You can see from the snapshot provided that purposeful formative assessment classroom techniques (FACTs) become learning opportunities.

The FACTs described in this snapshot are just a few of the ways teachers can utilize various strategies to elicit students' ideas, monitor changes in their thinking, provide feedback, engage students in self-monitoring, and support reflection on learning. Throughout the process, the teacher is taking into account how well students are moving toward a learning target and what needs to be done to bridge the gap between where students are in their understanding and where they need to be. The 50 FACTs in this book, combined with the 75 FACTs in Volume 1 (Keeley 2008, 2015) will help you build an extensive repertoire of strategies that will inform instruction and promote learning—through a process called formative assessment. While you may be tempted to skip ahead and go directly to Chapter 3 to choose FACTs you can use in your classroom, you are encouraged to read the rest of this chapter and Chapter 2, so you can make effective use of the FACTs and strengthen your knowledge of formative assessment in science instruction.

WHY 50 MORE FACTs?

Formative assessment is a process that informs instruction and supports learning, with instructional decisions made by the teacher or learning decisions made by the student being at the heart of the process. Dylan Wiliam describes the central idea of formative assessment as follows: "Evidence about learning is used to adjust instruction to better meet students needs—in other words, teaching is *adaptive* to the learner's needs" (2011, p. 46). This overarching idea is broken down into five key strategies (Leahy et al., 2005):

- Learning intentions and criteria for success
- Designing and facilitating productive classroom discussions, activities, and tasks that elicit evidence of learning
- Providing feedback that moves learning forward
- Activating learners as instructional resources for one another
- Activating learners as the owners of their own learning

This book includes 50 new techniques that will help teachers and students utilize these five key strategies. In addition to the 75 FACTs published in the first volume of this series (Keeley, 2008, 2015), and several of the FACTs in the mathematics version that are not repeated from science (Keeley and Tobey, 2011), teachers and teacher educators now have a total of 138 FACTs to embed throughout a cycle of instruction. Table 1.1 at the end of this chapter lists the combined collection of FACTs across all the current books in this series. A rich repertoire of FACTs helps learners to interact with assessment in a variety of ways—writing, drawing, speaking, listening, questioning, investigating, modeling, and more. Furthermore, these FACTs provide science-specific examples that are often lacking in general formative assessment resources.

Because science is a way of understanding the natural world, it is important to understand that science learners are constantly interacting with natural phenomena before they ever learn about scientific ideas in school. Preconceptions about natural phenomena are tenacious in science. That is why many of the FACTs in this book are designed not only to uncover what students have learned in the classroom through teacher-designed instruction but to also uncover ideas they bring to their learning that are formed outside of school that will affect what they learn in school. That is why many of the FACTs included in this book are used for elicitation purposes before the content is even taught.

Another feature of the 50 new FACTs included in this book that is important in navigating today's science education landscape is the connection to the *Next Generation Science Standards* (NGSS). The links to these disciplinary core ideas, cross-cutting concepts, and scientific and engineering practices are further described in the next chapter.

The first volume of this book, *Science Formative Assessment: 75 Practical Strategies for Linking Assessment, Instruction, and Learning* (Keeley, 2008, 2015) includes important background information. You are encouraged to obtain a copy of the first book as a companion to this volume, in order to read and learn more about the following:

- Types of formative assessment and purposes for using formative assessment
- The research that supports formative assessment
- Classroom environments that support formative assessment
- The connection between teaching and learning
- Making the shift to a formative-assessment centered classroom
- Integrating assessment and instruction
- Metacognition
- The SAIL Cycle (Science Assessment, Instruction, and Learning Cycle)
- Suggestions for selecting FACTs
- Suggestions for Implementing FACTs
- Using data from FACTs

Two purposes of formative assessment that are emphasized in this collection of 50 FACTs are elicitation of preconceptions and supporting productive science talk. Each of these purposes has special nuances in science that often are not explicitly addressed in general formative assessment strategies. While there are other purposes for which the FACTs are used in this book, it is important to understand these two purposes, as these are central to assessment *for* learning in science.

ELICITATION FACTs

Elicitation FACTs are designed to draw out students' existing ideas, many that come from experiences outside of school. For example, many students (and even adults) think the phases of the moon are caused by the shadow of the earth cast on the moon. This misconception makes sense when you consider the everyday experiences people have with shadows. From the time students are young children, before they even go to school, they have daily interactions with shadow phenomena. For example, a child playing outside might observe how an object blocks light from the sun and casts a dark shadow on the ground. This shadow conception is used to make sense of the changing face of the moon over a lunar month. Even after students are taught that the phases of the moon are the result of the positional relationship of the earth, moon, and sun, they may still revert back to a strongly held preconception. This is why elicitation of pre-existing ideas is an important part of science formative assessment.

Examples of elicitation FACTs in this book include, but are not limited to, *More A–More B Probes, Claim Cards, Ranking Tasks,* and *Slide Sort.* Elicitation FACTs are used at the beginning of a unit, cluster of lessons, or a single lesson to provide an opportunity for students to surface their initial ideas and give the teacher a sense of students' thinking prior to instruction. Elicitation FACTs are used to challenge students' existing beliefs or mental models, uncover common errors in terminology use or interpretation of representations, and expose faulty explanations of common or familiar phenomena. Using a FACT for elicitation promotes learning by engaging students, stimulating further thinking, and setting the stage for the activities and/or discussion that will follow. As a pre-assessment that informs instruction, it helps the teacher gauge initial student thinking, plan for enacting or modifying the lesson to follow, or choose a new lesson that better addresses where students are in their conceptual understanding. When an elicitation FACT is selected, it should be designed so that every student can have an answer or opinion, regardless of whether they are correct. The intent of using an elicitation FACT is that every student will have an opportunity to share their thinking either verbally or through writing. The data from elicitation FACTs help the teacher to set learning goals for activities designed to address students' ideas, as well as eliminate activities that may not be necessary if students demonstrate conceptual understanding.

Early in the school year as you enact formative assessment, some students may feel uncomfortable sharing their initial ideas in a whole-class setting. This will eventually change as you work to establish a classroom culture that makes it safe to discuss and evaluate peer ideas. Your goal should be to eventually move students toward public sharing and critique of their thinking. In the meantime, you might consider using an anonymous elicitation strategy such as *Fingers Under Chin* or *Extended Sticky Bars.* One way you can anonymously share students' thinking as they are writing their responses to a FACT is to say, "As I walked around the room, I noticed several of you wrote . . . "; or, after you have collected students' written responses to a FACT and scanned through them, you might say, "I noticed several of you think . . . "; or you might list students' ideas on a chart as an initial record of the class thinking without critique at this point. These anonymous techniques provide a way for students to see that not everyone has the "right answer" and that members of a scientific community often have alternative explanations and ways of thinking. The goal is to work toward a common, accepted understanding by considering the ideas of others and gaining new information that can be used to construct scientific explanations. These elicitation FACTs also show students that you, the teacher, value their ideas regardless of whether they are right or wrong. Eventually students transition toward publicly sharing their thinking as they experience a learning environment where it is safe and interesting to share different ideas and ways of thinking.

First and foremost, remember the goal of elicitation is to promote student thinking, mentally commit to an answer, and participate in discussions (either immediately after an elicitation question is posed and/or in follow-up discussions) that reveal students' existing ideas. The biggest challenge for teachers right after students respond to an elicitation FACT or during follow-up elicitation discussions, is to refrain from giving the answer and/or passing judgment on students' thinking. Let students grapple with ideas, while you guide them toward scientific understanding.

Provide an opportunity for students to talk in pairs or in small groups before facilitating a whole-class discussion following use of an elicitation FACT. Circulate and listen as students discuss their ideas and defend their arguments. When pairs or small groups are talking, the teacher's role must be as a facilitator who draws out the students' ideas without indicating right or wrong answers. Once students are told or are cued as to the best answer, their thinking and questioning may stop. You want your students to keep thinking and discover the explanation for themselves, while you are gathering evidence of conceptual understanding or misunderstanding.

SUPPORTING PRODUCTIVE SCIENCE TALK

"In order to process, make sense of, and learn from their ideas, observations, and experiences, students must talk about them. Talk, in general, is an important and integral part of learning, and the students should have regular opportunities to talk through their ideas, collectively, in all subject areas. Talk forces students to think about and articulate their ideas. Talk can also provide an impetus for students to reflect on what they do—and do not—understand" (Michaels et al., 2008, p. 88). As students talk, teachers listen. A treasure trove of formative assessment data can be mined merely by carefully listening to students talk about their ideas and justify their thinking.

However, talk alone is not enough to promote learning and inform instruction. Science talk must be productive science talk. Productive talk is carefully orchestrated by the teacher using discussion norms in which all students are held accountable for each other's and their own learning in a respectful, safe environment. Furthermore, students must have something interesting to talk about and they must be engaged through a variety a formats and techniques the teacher purposely uses to facilitate discussion. Several of the FACTs in this book are designed to be used in various talk formats.

For example, after using an elicitation FACT in a small-group discussion, the teacher may invite the whole class to take part in a discussion to share and critique the various ideas held by students. As you chart or make a visual record of the class ideas, make sure all students have an opportunity to share any thinking that may differ from the ideas already listed, so you have a complete record of the class thinking. If you noticed during pair or small-group talk any significant thinking that was not shared during the process of listing the class ideas, you might say something like, "I heard one group talking about . . ." and add that to the list. Using *Talk Moves* helps encourage discussion.

Once you have generated a list of class ideas, facilitate a discussion to critique ideas by engaging the students in argumentation. The goal of argumentation is to seek understanding by putting forth ideas and persuading others to agree with your thinking, supporting it with evidence and sound reasoning. Encourage students to support their arguments in favor of or in rebuttal of one of the ideas listed by sharing evidence from previous experience, class activities, data from investigations, information from valid sources, and logic. As they engage in discussion and critique of arguments, the class usually comes to a consensus that some ideas can be discarded, narrowing the list to "our best thinking so far." This also provides the teacher with insight into student thinking and the extent to which the class is moving toward the scientific idea.

Sometimes the discussion helps the class come to an accepted common understanding of the best answer and of why it is considered the best answer. Other times, students may leave class with unresolved ideas, "hanging out in uncertainty" until the next class period, when the teacher provides an opportunity for them to re-examine their thinking, test ideas, or gather more information to resolve the differences in their thinking.

Some FACTs, especially ones that involve probing questions, can be discussed and resolved in less than 45 minutes; others may take a few days of carefully designed lessons. The formative nature of the FACT allows the teacher to encourage discourse and evidence-based learning experiences that will help students reshape and refine their thinking, keeping them engaged in moving toward the learning target until they have acquired the evidence they need to develop a conceptual understanding. Examples of FACTs that are used in talk formats include, but are not limited to, *I Think-We Think, Four Corners Jigsaw, Lines of Agreement*, and *VDR.*

The challenge for teachers in using talk formats for formative assessment is deciding what to do with the student ideas you uncover during the use of talk and argument FACTs. Listening to students provides a lot of formative assessment data. Once you have uncovered these ideas, you will need to decide which ideas need to be considered in planning your next moves in instruction. It helps to categorize the ideas into valid ideas, partially valid ideas, minor misunderstandings, and major misconceptions. As you distill students' ideas that emerge from science talk, think about your next steps in moving them toward the learning target. You may need to do the following:

1. Elicit further evidence of preconceptions or other conceptual obstacles
2. Confront students with examples that will challenge their existing ideas
3. Address misunderstandings related to the language of science and other technical vocabulary
4. Reteach something that was taught previously but in a different context
5. Provide scaffolds to support students' developing understandings
6. Identify students who can be resources for other students during the lessons that will follow
7. Revisit the learning intentions and success indicators and adjust accordingly, depending on where students are in their understanding
8. Provide opportunities for students to access new information they can use to refine, reshape, or further develop their ideas

Several excellent resources are available to help you learn more about productive science talk and how to orchestrate science discussions in your classroom. The Appendix contains resources, tools, and strategies for engaging students in productive science talk. These will help you use the FACTs that involve students in sharing and defending their ideas in a variety of talk formats.

NEXT STEPS

Remember, learning is like crossing a bridge. The elicitation question surfaces where students are at the beginning of the bridge. The bridge is the connection between students' initial ideas and the scientific understanding. The instructional opportunities you provide through talk as well as investigative experiences will take them over the bridge, sometimes in leaps, sometimes in small steps. Eventually you want students to end up on the other side of the bridge, without being carried over the bridge by the teacher, although some students may need a helping hand to guide them. It is that moment when the student realizes he or she has crossed over the bridge on their own, leaving ideas that no longer work for him or her behind, that results in powerful conceptual learning! As you use the FACTs described in Chapter 3, think about how they can be used to help you construct that conceptual bridge. Examine the links to the NGSS provided in the next chapter, as many of you will be building new bridges between where your students are and where they need to be in order to address the performance expectations in the NGSS or your existing state standards.

As you try out the FACTs in Chapter 3, add them to your growing repertoire of purposeful formative assessment techniques. Table 1.1 combines all the FACTs across the three books that currently exist for a total of 138 techniques. Some of them are new, and several have been around for decades. Some are specific to science, while others can be used across disciplines. Be purposeful in selecting a FACT—know why you should use it and what you will learn from using it. But start small! As Dylan Wiliam, a leader in formative assessment, wisely points out when being presented with so many formative assessment techniques and choices, "too much choice can be paralyzing—and dangerous. When teachers try to change more than two or three things about their teaching at the same time, the typical result is that their teaching will deteriorate and they go back to doing what they did before" (2011, p. 161). His advice is to choose one or two to try out in your classroom. If they seem to be effective, practice using them until they become second nature. If they do not seem to be effective, consider how you can modify them to fit your teaching style and the needs of your learners or ask other teachers who are using them for advice on how to make them work. Not all of these 138 techniques will work for all teachers, but I am confident that you will find a few that truly work for you and transform your teaching and your students' learning.

Table 1.1 138 Science and Mathematics Formative Assessment Classroom Techniques (FACTs)

1. A&D Statements ⊙→
2. Always, Sometimes, or Never →|
3. Agreement Circles ⊙→
4. Annotated Student Drawings ⊙
5. B-D-A Drawings |
6. Card Sorts ⊙→
7. Claim Cards |
8. CCC—Collaborative Clued Corrections ⊙→
9. Chain Notes ⊙
10. C-E-O-SE |
11. Comments Only →|
12. Commit and Toss ⊙→
13. Comparison Overlap Probes |
14. Concept Attainment Cards →|
15. Concept Card Mapping ⊙→
16. Concept Cartoons ⊙→
17. Concept Mix-Up Probes |
18. Confidence Level Assessment |
19. Create the Problem →
20. Cross-Cutter Cards |
21. CSI (Color–Symbol–Image) |
22. Data Match ⊙
23. Diagnostic Collections |
24. Directed Paraphrasing ⊙
25. Enhanced Multiple Choice |
26. Every Graph Tells a Story →
27. Everyday Mystery Stories |
28. Example, Non-Example →|
29. Explanation Analysis ⊙
30. Extended Sticky Bars |
31. Eye Contact Partners |
32. Fact-First Questioning ⊙→
33. Familiar Phenomenon Probes ⊙
34. Feed Up, Feedback, and Feed Forward →|
35. Fingers Under Chin |
36. First Word–Last Word ⊙
37. Fishbowl Think Aloud ⊙
38. Fist to Five ⊙→
39. Focused Listing ⊙
40. Four Corners ⊙→
41. Four Corners Jigsaw |
42. Frayer Model ⊙→
43. Friendly Talk Probes ⊙→
44. Gallery Walk |
45. Give Me Five ⊙→
46. Group Frayer Model |
47. Group Talk Feedback |

⊙ In *Science Formative Assessment, Volume 1: 75 Practical Strategies for Linking Assessment, Instruction, and Learning* (Keeley 2008, 2015).

→ In *Mathematics Formative Assessment: 75 Practical Strategies for Linking Assessment, Instruction, and Learning* (Keeley and Tobey, 2011).

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48. Guided Reciprocal Peer Questioning ⊙
49. Homework Card Sort |
50. Hot Seat Questioning →|
51. Human Scatterplots ⊙→
52. I Think–I Rethink |
53. I Think–We Think ⊙
54. I Used to Think . . . But Now I Know . . . ⊙→
55. Informal Student Interviews ⊙
56. Interest Scale ⊙
57. Is It Fair? →
58. Juicy Questions ⊙
59. Justified List ⊙→
60. Justified True or False Statements ⊙→
61. K-W-L Variations ⊙→
62. Learning Goals Inventory (LGI) ⊙→
63. Learning Intentions |
64. Let's Keep Thinking |
65. Lines of Agreement |
66. Look Back ⊙→
67. Magnetic Statements |
68. Matching Cards →|
69. Mathematician's Ideas Comparison →
70. Missed Conception ⊙
71. More A–More B Probes →|
72. Muddiest Point ⊙→
73. No-Hands Questioning ⊙→
74. Odd One Out ⊙→
75. Opposing Views Probes ⊙→|
76. Overgeneralization Probes →
77. Paint the Picture ⊙
78. Partner Speaks ⊙→
79. Pass the Question ⊙
80. Pass the Problem →
81. P-E-O Probes ⊙→
82. Peer-to-Peer Focused Feedback →
83. A Picture Tells a Thousand Words ⊙→
84. Picture This |
85. Plus–Delta |
86. PMI (Plus–Minus–Interesting) |
87. POMS—Points of Most Significance ⊙→
88. Popsicle Stick Questioning ⊙→
89. Prefacing Explanations ⊙
90. PVF—Paired Verbal Fluency ⊙→
91. Question Generating ⊙→
92. Ranking Tasks |
93. RAQ Feedback |
94. Recognizing Exceptions ⊙

⊙ In *Science Formative Assessment, Volume 1: 75 Practical Strategies for Linking Assessment, Instruction, and Learning* (Keeley 2008, 2015).

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(Continued)

Table 1.1 (Continued)

95. Reflective Toss ǀ	116. Think-Alouds →
96. Refutations ⊙	117. Thinking Log ⊙→
97. Representation Analysis ⊙	118. Think-Pair-Share ⊙→
98. RERUN ⊙	119. Thought Experiments ⊙→
99. Response Cards →	120. Three-Minute Pause ⊙→
100. Same A–Same B Probes →	121. Three-Two-One ⊙→
101. Scientists' Ideas Comparison ⊙	122. Thumbs Up, Down, and Sideways ǀ
102. Sequencing ⊙→	123. Traffic Light Cards ⊙→
103. Slide Sort ǀ	124. Traffic Light Cups ⊙→
104. Sticky Bars ⊙→	125. Traffic Light Dots ⊙→
105. STIP—Scientific Terminology Inventory Probe	126. Traffic Light Sliders ǀ
106. Strategy Harvest →	127. Two-Minute Paper ⊙→
107. Strategy Probe →	128. Two or Three Before Me ⊙→
108. Student Evaluation of Learning Gains ⊙→	129. Two Stars and a Wish ⊙→
109. Student Interviews →	130. Two-Thirds Testing ⊙→
110. Success Indicators ǀ	131. Vernacular Probes ǀ
111. Synectics ⊙	132. Volleyball—Not Ping Pong! ⊙→
112. Talk Moves ǀ	133. VDR (Vote, Discuss, Revote) ǀ
113. TAR (Target, Analogy, Reflection) ǀ	134. Wait Time Variations ⊙→
114. Terminology Inventory Probe ⊙→	135. What Are You Doing and Why? ⊙→
115. Ten-Two ⊙→	136. What Did I Learn Today? ǀ
	137. Whiteboarding ⊙→
	138. Word Sort →ǀ

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