Chapter 13
Formative Assessment and Mathematics Teaching: Leveraging Powerful Linkages in the US Context

Megan Burton, Edward A. Silver, Valerie L. Mills, Wanda Audrict, Marilyn E. Strutchens and Marjorie Petit

Abstract Despite compelling evidence of the benefits of formative assessment on student learning, it is infrequently or unsystematically implemented in many U.S. classrooms. Consequently, the National Council of Supervisors of Mathematics (NCSM) and the Association of Mathematics Teacher Educators (AMTE) collaborated to relate formative assessment to other aspects of effective mathematics teaching, rather than treating it as an isolated topic. The Formative Assessment Initiative makes explicit the connection between formative assessment strategies and other instructional frameworks and tools intended to promote improved teaching and learning of mathematics. Because of its focus on promoting high quality mathematics teaching, the work of this U.S.-based project transcends boundaries and offers ideas that should be useful to mathematics teacher educators across the globe.

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13.1 Introduction

Assessment is an ongoing, informative process that is integral to effective instruction. It is implicated in teacher-student interactions that support students' communication and their thinking and the development of their understanding of mathematical ideas. A complete classroom assessment program contains both summative and formative assessments. Summative assessment focuses on assessment *of* student learning for evaluation (Black et al. 2004); formative assessment is referred to as assessment *for* learning (Broadfoot 2008; Stiggins 2005). This paper shares ideas gained from an initiative of the National Council of Supervisors of Mathematics (NCSM) and the Association of Mathematics Teacher Educators (AMTE) to promote an intentional and systematic approach to implementing formative assessment in U.S. mathematics classrooms. Although this paper is about the process of this initiative in the United States, the call to make formative assessment more explicit in mathematical professional development is a global issue. Linking this central practice to effective mathematics instruction to other professional development or educational experiences for teachers helps make visible the interlinking nature of effective teaching practices.

The National Council of Supervisors of Mathematics (NCSM) and the Association of Mathematics Teacher Educators (AMTE) advocate for instructional leaders to promote the use of formative assessment in effective mathematics instruction (NCSM/AMTE 2014). Although effective instruction involves deeply integrated formative assessment, this isn't always made visible during professional development and instructional discussions. Therefore, a joint task force was formed to promote and support the attention paid to formative assessment practices by mathematics instructional leaders as they worked with preservice and inservice teachers. In addition, the task force sought to better understand members' current thinking about and attention to formative assessment, other popular instructional frameworks, tools, and approaches (which for the purposes of this paper, will be called approaches) and the connections that might exist among them. Toward this end, the task force developed a joint position paper on formative assessment (NCSM/AMTE 2014), conducted a survey of its membership, and shared information about formative assessment in sessions at national and international conferences and through publications (Petit and Bouck 2015; Silver and Smith 2015).

In addition, international experts on mathematics teacher education and professional development, who had worked with and/or contributed to the development of selected approaches to teaching, participated in a working meeting at the University of Michigan funded from the U.S. National Science Foundation (DRL1439366). The five approaches of focus at this meeting were *Culturally Responsive Pedagogy* (Gay 2013), *Cognitively Guided Instruction* (Carpenter et al.

2014), *Classroom Discourse Tools* (Smith and Stein 2011), *Response to Intervention* (Gersten et al. 2009), and the *Mathematical Tasks Framework* (Stein et al. 2009). The approaches that were examined were selected based on feedback from the survey administered to mathematics teacher educators and supervisors about their use of assessment in teacher education courses and professional development opportunities. The membership overwhelming saw formative assessment as important to their work and effective teaching, and these five approaches were identified as the most widely utilized. Therefore, the meeting focused on whether and how formative assessment might be a more explicit focus in the work of these popular approaches.

A significant outcome of this working meeting was that experts familiar with these selected approaches recognized important connections between formative assessment practices and the approach for which they are associated, while acknowledging this connection hasn't always been explicit in the professional development. Further, it appears to a growing group of experts that explicitly making the role of formative assessment within their approach visible to educators might both advance understanding and use of their framework and deepen educators' understanding and use of formative assessment practices. This paper focuses on the importance of formative assessment in instruction by examining how it is seen in various common instructional approaches. Below we first discuss important elements of formative assessment practices and then make connections to its presence within the additional approaches we have studied. Similar connections between formative assessment and other important approaches utilized globally can also be found. This paper focuses on approaches utilized in the United States because this is where the work was conducted, but many of these (e.g., Cognitively Guided Instruction, Mathematical Tasks Framework) are also known and used across the globe.

13.2 Formative Assessment

Formative assessment focuses on using information about student thinking to inform the instruction so as to improve learning (Black et al. 2004). Ideally, it would be a prominent part of lesson planning and instructional enactment. It is a deliberate process which involves teachers and students gathering and utilizing information about what students know and can do. It is cyclical and provides feedback to students about their progress and guides decisions about the next instructional steps to take. It includes eliciting information about what students know and are learning, and uses this information to guide decisions about short-term, mid-range, and long-range instructional issues. Formative assessment—eliciting and using information about student thinking—is one of eight effective mathematics teaching practices emphasized in the *Principles to Action* (National Council of Teachers of Mathematics [NCTM] 2014). By understanding what

students know and how they are thinking, teachers can adjust instruction to maximize learning potential for all students.

Wiliam (2011, p. 45) described three instructional processes associated with formative assessment: finding out where the students are and what they are thinking, knowing where they will be going, and determining how to get them to this destination. These three processes are found in the five aspects of instruction that characterize effective formative assessment in classrooms described by Leahy et al. (2005). These five aspects include:

(1) Sharing clear learning goals and benchmarks for success;
(2) Designing lessons that involve successful classroom discussions, questions, and instructional tasks;
(3) Enhancing and progressing learning through feedback;
(4) Fostering student ownership of learning and;
(5) Creating an environment where students serve as resources for one another.

In classrooms where teachers regularly employ formative assessment strategies, student learning is enhanced (Black and Wiliam 2010; Ehrenberg et al. 2001; Popham 2013). For example, Ehrenberg et al. (2001) estimated the impact of formative assessment on student achievement to be four to five times greater than the effect of reducing class size. However, despite its obvious importance, formative assessment has not taken hold in U.S. mathematics instruction. We hypothesize that this is due, at least in part, to inadequacies in its treatment in the initial preparation and continuing professional development of mathematics teachers. In these settings, formative assessment is typically addressed in isolation, rather than holistically connected to other aspects of effective mathematics teaching. Formative assessment is much more than the addition of an exit slip, test, or observation; it is interwoven into the fabric of teaching and learning. Effective instruction and formative assessment are indivisible (Black and Wiliam 2010). Because formative assessment is such a critical element of effective teaching within any frameworks, tools, and approaches (FTA), teacher leaders, supervisors, mathematics coaches, and teacher educators need to firmly understand formative assessment strategies, be able to effectively implement them in the classroom, and promote the strategies throughout their work with teachers and others.

13.3 Making Formative Assessment Visible for Teachers

One way for teacher educators, teacher leaders, and mathematics coaches to promote formative assessment strategies is through providing sustained, meaningful professional development opportunities which support and model the effective use of formative assessment in the classroom. Making formative assessment explicit in professional development allows teachers to see how integral it is in effective teaching. Teachers may develop and/or enhance their use of the five formative

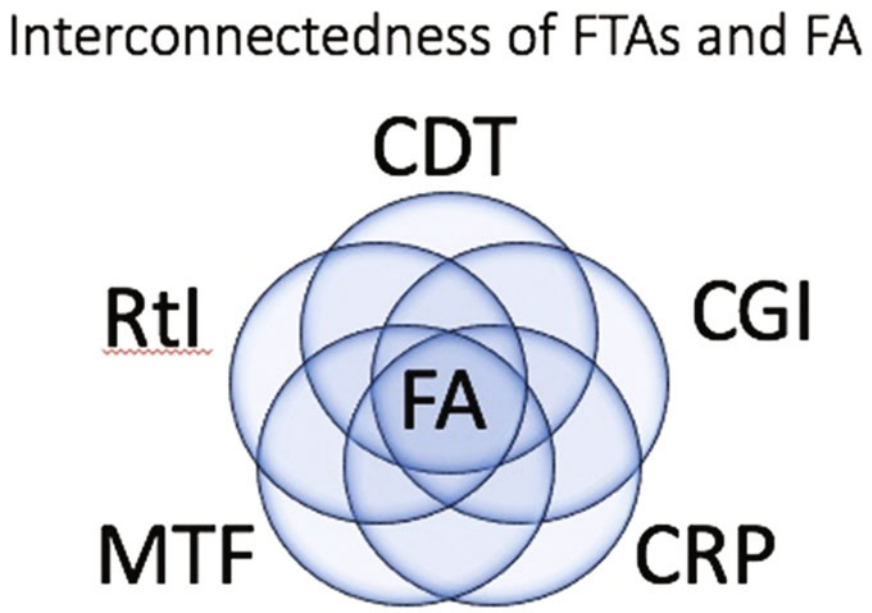

Fig. 13.1 The interconnectedness of frameworks, tools, or approaches (FTA) and formative assessment (FA)

assessment strategies described in Leahy et al. (2005) through professional development opportunities that connect to their own classrooms.

When providing professional development, teacher leaders, supervisors, coaches, and educators need to explicitly discuss the role formative assessment plays in the classroom instructional frameworks they are utilizing, such as Culturally Responsive Pedagogy (CRP), Cognitively Guided Instruction (CGI), Classroom Discourse Tools (CDT), Response to Intervention (RtI), and the Mathematical Tasks Framework (MTF) (see Fig. 13.1). Although each of the approaches examined may have some overlap with other approaches, formative assessment is central to each and is a common thread. This could be said of many other common approaches that are utilized around the world. Teachers need to see the integral role formative assessment plays in each of these research-based frameworks.

Below are examples of how formative assessment is interwoven into the approaches examined by this initiative. However, connections can be made to other approaches that focus on effective teaching and learning.

13.3.1 Culturally Responsive Pedagogy (CRP)

Culturally Responsive Pedagogy places focus on the local context and culture of the students and thus empowers students. This notion of connecting to student culture

and context is relevant globally and "exemplifies the notion that instructional practices should be shaped by the sociocultural characteristics of the settings in which they occur, and the populations for whom they are designed" (Gay 2013, p. 63). Communication is key in this approach. For teachers to understand their students, they need to listen and observe. This involves utilizing formative assessment. When Culturally Responsive Pedagogy is implemented, the need for diversity in thinking about mathematics (e.g., style, pace, connections) is appreciated. Therefore, the evidence will be diverse as well. By noting how students think about and approach mathematical situations, teachers are able to adjust and build the most effective learning opportunities. Formative assessment allows students the opportunity to share their views, experiences, and thinking and it is a natural part of this approach.

When offering professional development on Culturally Responsive Pedagogy, it is important to help teachers identify the cultural aspects of mathematics and the importance of building upon students' strengths. Considering ways to collect evidence that honors the cultural diversity in the classroom and how this can be used to drive instruction can be a useful element of professional development in this approach. Exploring how a teacher's own experience shapes the instruction and assessment of student learning is critical in professional development. For example, in a classroom where debate of mathematical ideas is encouraged, it would be important for a teacher to recognize that some families do not support children debating adults rather than interpret silence as lack of engagement by a student. The experience of justifying and critiquing reasoning may need to be altered to empower these students (by having students debate each other or finding alternate ways that develop classroom community while supporting individual cultural norms). For more information about Culturally Responsive Pedagogy in mathematics education, the reader may find *The Impact of Identity in K-8 Mathematics: Rethinking Equity-based Practices* (Aguirre et al. 2013) to be a useful resource.

13.3.2 Cognitively Guided Instruction (CGI)

Cognitively Guided Instruction is a framework that focuses on teachers understanding student thinking and utilizing this thinking to guide instruction. The framework utilizes problem types and solution strategies to help inform teachers and students about student thinking and make appropriate plans to build upon student knowledge (Carpenter et al. 2014). Using this framework, teachers are able to examine the difficulty of problems and scaffold instruction based on student responses to various problems.

Consider the following scenario. Composing numbers greater than 10 is a learning goal for a first-grade class based on state standards. Individual students have more specific learning goals, based on analysis of their individual prior work and understanding of the framework (e.g., using the correct strategy to solve a problem, counting by ones, making groups of ten to solve the problem, utilizing

place value). Cognitively Guided Instruction focuses on individual learning; each child has a specific learning goal. The problem given will be open enough that it contains multiple entry points to accommodate the diversity in the classroom. The instructional decisions for each child are based upon analysis of prior student work. The teacher will ask specific questions of each learner, based on his or her individual learning goals. Either way, teachers circulate among the room as students work independently. Teachers take anecdotal notes, pose questions, and utilize these observational notes to engineer whole class discussions at the end. Although all five formative assessment strategies (Leahy et al. 2005) are present in this framework, students as owners of their learning is central to Cognitively Guided Instruction.

When providing professional development related to this approach, it is essential to practice gathering information about student thinking, interpreting this information, and using it to plan future instruction. During professional development, teachers learn about the problem types and their progressive difficulty. They utilize student samples to begin to understand student thinking and identify scaffolding necessary for future learning. Teachers begin to see the way the evidence of student thinking can effectively guide instruction. During professional development, teachers see videos of students solving problems, conduct interviews with students, and examine classroom embedded work. These experiences are all useful to the formative assessment cycle. Professional development leaders need to explicitly ensure teachers recognize the experiences as examples of formative assessment. For more information on this framework and other Cognitively Guided Instruction Frameworks see Carpenter et al. (2014).

13.3.3 Classroom Discourse (CD)

Classroom Discourse focuses on understanding the various forms of discourse in the classroom. Moreover, Classroom Discourse involves creating more productive, student-centered discussions, intentionally planning questions that elicit thinking, asking students to clarify their thinking, and encouraging others to engage. Thus, this approach involves planning the discourse, but also being purposeful about the discourse based on observations during instruction and reflecting on discourse needed to further the learning in future lessons. Students need to be empowered to make sense of their own mathematical thinking, as well as the thinking of their peers. Discourse focuses on uncovering both the understanding and misunderstandings that are present and utilizing this information to inform future instruction. An example of providing feedback to move the learning forward would be a teacher saying, “One group found 32 and another group found 34. Does anyone have a prediction of why their answers might be different?” Helping students own their learning might involve asking, “Does anyone want to revise his or her answer? If so, can you explain why?”

When offering professional development around Classroom Discourse, it is important for teachers to see how discourse moves connect to formative assessment. When selecting tasks, teachers can analyze opportunities for formative assessment. While learning discourse strategies, teachers need to explicitly see how these strategies can be utilized during the instruction cycle to formatively assess student learning. Professional development can include using case studies to consider evidence of learning and how data can be used to form future instruction. For more information on this approach see *Five Practices for Orchestrating Productive Mathematical Discussions* (Smith and Stein 2011).

13.3.4 Response to Intervention (RtI)

Response to Intervention is a multi-tiered instructional support system aimed at meeting the diverse needs of students. A triangle figure is often used as a visual for this 3-level support system. It is based on the belief that if all students receive universal, high quality, engaging lessons, that approximately 80% of the students will have their needs met. This universal level of instruction is known as tier 1. Students who do not respond to this core instruction receive high quality supplementary instructional strategies, which is the only additional instruction needed by approximately 15% of the students; this targeted instruction is known as tier 2. Approximately 5% of classroom students will need intensive, individualized strategies, because they don't respond to tier 2 interventions; this level of instruction is known as tier 3.

Conducting diagnostic interviews and planning interventions based on evidence of student struggles is at the heart of Response to Intervention. Ensuring teachers have shared expectations about the use of formative assessment when utilizing this approach is essential. Each tier of instruction requires teachers to formatively assess progress to inform whole group, small group, or individual instruction. Formative assessment at all levels allows the teacher to identify both the strengths as well as areas of focus for instruction of all learners. Formative assessment goes beyond exploring if students have the right answer and explores student thinking, which is key to address issues they may have. Professional development of Response to Intervention should include various types of formative assessment strategies that could be useful at each tier. In addition, discussing which Response to Intervention assessments are more summative rather than formative is key. Connecting the five formative assessment strategies (Leahy et al. 2005) to the formative assessment that should occur in classrooms using this approach allows teachers to note the important role it plays in quality instruction at all levels. For more information, see *Assisting students struggling with mathematics: Response to Intervention (RtI) for elementary and middle schools* (Gersten et al. 2009).

13.3.5 Mathematical Tasks Framework (MTF)

The Mathematical Tasks Framework is a tool that allows teachers to discuss various tasks that occur during instruction and the different learning opportunities they provide. Teachers examine and identify the cognitive demand involved in tasks and the processes a task goes through (Stein et al. 2009). Formative assessment happens everywhere in the Mathematical Tasks Framework. However, it is especially visible as teachers determine when to move to the next phase of the lesson, how the evidence collected indicates cognitive demands, and how student work relates to the goal and informs future instruction. The Mathematical Tasks Framework supports teachers in analysis of tasks to determine the level of thinking possible for students and the most effective way to set up a task to reach its maximum potential of student growth. The set-up or launch of a task communicates the expectations and learning goals for students, which is one of the five strategies listed by Leahy et al. (2005).

When implementing professional development on the Mathematical Tasks Framework, it is important that leaders provide opportunities for teachers to explore the formative assessment evidence that can be gained from various tasks and discuss how this evidence can be utilized to move learning forward. For more information see *Implementing standards-based mathematics instruction: A casebook for professional development, Second Edition* (Stein et al. 2009).

13.4 Discussion

To address and dispel this view of formative assessment as something "extra," we advocate that teacher educators and professional development specialists explicitly connect formative assessment to other frameworks, tools, and approaches utilized in their work. Despite their differences, the approaches used in our work emphasize important aspects of formative assessment, such as eliciting students' thinking and using this information to inform instructional decisions.

We argue that the explicit foregrounding of formative assessment in connection with these approaches can both help support the increased, effective use of formative assessment in mathematics teaching and bring greater coherence to professional development. The National Council of Teachers of Mathematics (2014) highlights the importance of a coherent curriculum that organizes and integrates important content to empower students to make connections and build upon existing ideas. This same coherence is important in professional development opportunities for teachers. Providing experiences that make visible the connections among important instructional ideas is key to developing new understandings.

The teacher's role in formative assessment takes many forms including facilitating classroom discussions, questioning, eliciting student thinking, analyzing student work, providing feedback to students, and using formative assessment data

to make instructional decisions. "In a classroom that uses assessment to support learning, the divide between instruction and assessment blurs" (Leahy et al. 2005, p. 22). Teaching plans can be adjusted based on the information gathered through questioning, classroom discussions, observation, and other formative assessment strategies. Just as the line between instruction and assessment blurs, the lines between the eight mathematics teaching practices (NCTM 2014) blur, because each impacts the effectiveness of the other. This is why explicitly sharing the role of formative assessment in various approaches is needed (see Fig. 13.2) to enable teachers to appropriately interpret evidence from formative assessment data and respond in a manner that moves students forward in their thinking. Figure 13.2 shares where various approaches fall in relation to elements of instruction. However, it illustrates that formative assessment is seen in all three elements of instruction on the chart.

Evidence from participants in the working meeting and responses from those who have attended conference sessions regarding this approach to treating formative assessment have been very encouraging. For example, 18 of the 19 working meeting participants indicated that they had developed a new and increased appreciation of the importance of formative assessment and its connection to the approaches they use, and they planned to implement these ideas in their work. This work has informed multiple presentations and publications. However, the true test is the impact this approach has on teachers and their ability to see formative assessment within the approaches and instruction they implement daily in the classroom. Future research on the impact of implementing professional development of a framework, tool, or approach with specific, explicit attention to formative assessment is needed. Does this provide coherence in teacher views on instruction and/or professional development? Does it change practices in formative assessment? How does this approach impact participants' views of the frameworks, tools,

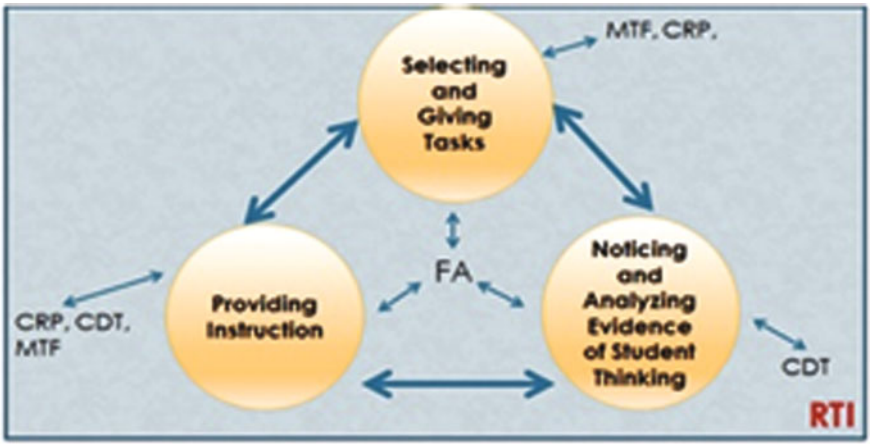

Fig. 13.2 Sample of connections of frameworks, tools, and approaches to formative assessment

and approaches? Each of these questions could be explored in future studies. In addition, examinations of the place of formative assessment in frameworks, tools, and approaches that are widely used in other countries would be useful. It would provide more strength to global arguments on the integral role of formative assessment in instruction.

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