Improving Student Achievement in Mathematics Through Formative Assessment in Instruction

A joint position paper of the Association of Mathematics Teacher Educators (AMTE) and the National Council of Supervisors of Mathematics (NCSM).

It's really not surprising that formative assessment works so well. What is surprising is how few teachers use the process.
—James Popham, "Formative Assessments 'Advocatable' Moment"

Our Position

The National Council of Supervisors of Mathematics (NCSM) and the Association of Mathematics Teacher Educators (AMTE) affirm the centrality of research-based, mathematically focused, formative assessment—a key element in the national effort to improve mathematics proficiency. Formative assessment needs to be intentionally and systematically integrated into classroom instruction at every grade level. This requires adequate attention in the preparation of new teachers of mathematics and in the continuing education and professional development of current teachers.

What Is Formative Assessment?

Formative assessment is a process of gathering evidence within the stream of instruction in order to inform teaching and learning (Black et al 2004).

To be considered formative, the evidence must be "elicited, interpreted, and used by both teachers and learners" (Wiliam 2011, 43). In contrast, summative assessment is used to evaluate progress and achievement, assign grades and appraise programs. "Formative assessment involves getting the best possible evidence about what students have learned and then using this information to decide what to do next" (p 50). "In a classroom that uses assessment to support learning, the divide between instruction and assessment blurs. Everything students do—such as conversing in groups, completing seatwork, answering and asking questions, working on projects, handing in homework assignments, even sitting silently and looking confused—is a potential source of information about how much they understand" (Leahy et al 2005). "When classroom practice is based on formative assessment, teachers and students together develop a framework for what can be expected in students' learning, for what it means to move toward intended mathematics learning goals, and for a common goal of continuous and progressive learning. Formative assessment is a crucial tool for simultaneously improving classroom practice and students' performance" (Petit and Zawojewski 2011).

Evidence from Research and Practice That Supports Our Position

There is a growing body of research emphasizing the use of formative assessment in classroom instruction as a means to improve student achievement. In their synthesis of studies, Black and Wiliam (1998) note evidence of greater student achievement in classrooms where teachers use such techniques. Similar findings are replicated in a meta-analysis by Ehrenberg et al (2001). In particular, they report the impact of formative assessment on student achievement being four to five times greater than the effect of reducing class size.

Additionally, in an analysis and synthesis of studies, Leahy et al (2005) identify strategies supporting the use of formative assessment:

- Clarifying and sharing learning intentions and criteria for success.
- Engineering effective classroom discussions, questions and learning tasks.
- Providing feedback that moves learners forward.
- Activating students as the owners of their learning.
- Activating students as resources for one another.

Clarifying and Sharing Learning Intentions and Criteria for Success

One technique to clarify and share learning intentions and criteria shown to positively impact student achievement is when students analyze their work as they proceed through a task using explicitly stated criteria for performance (White and Fredrickson 1998). Another strategy is to give students anonymous samples of student work, such as from another class or different year, on a task that requires students to do such work. Students review and analyze the samples and communicate what is good in the better samples and what is lacking in the weaker ones.

Implicit to this strategy is explicitly stating and engaging students in the mathematics goal of a lesson, task or activity. Understanding and being able to articulate the mathematics goal provide students with a clear idea of where they are going and enables them to reflect on progress toward the goal rather than aimlessly working through a lesson.

Engineering Effective Classroom Discussions, Questions and Learning Tasks

This strategy involves three interrelated activities: (1) engaging students in tasks and activities that provide insights into their thinking; (2) teachers and students listening and analyzing student discussions and artifacts interpretatively, not just from an evaluative perspective; and (3) implementing instructional strategies designed to engage all students in tasks, activities and discussions (Wiliam 2011).

Wiliam (2011) suggests only two reasons to ask questions in a classroom: "one, to cause thinking and two, to provide information for the teacher about what to do next" (p 70). To do this, the task should be selected based on its ability to reveal student thinking and understanding around important mathematics concepts and practices. In addition, teachers should consider the potential of a task to reveal student progress along a developmental progression and its potential to elicit misconceptions and common errors. Engineering effective classroom discussions, questions and learning is also dependent on both teacher's and student's ability to listen interpretatively; that is, not just listening for the right answers but listening for evidence about student thinking to inform the next instructional steps.

"High engagement classroom environments appear to have a significant impact on student achievement" (Wiliam 2011, 81). When students are highly engaged, they are absorbed in activities, tasks and discussions using techniques, such as

think-pair-share, wait time, cold calling, sharing student-generated solutions and all student response systems such as mini whiteboards and exit cards. These and other instructional strategies provide teachers many opportunities to check for understanding during or right after a lesson, rather than waiting for homework, quizzes and tests for evidence of what sense students are making of the mathematics.

Providing Feedback That Moves Learners Forward

It has been known for some time that just checking answers as right or wrong and giving scores, negatively impacts student learning as compared to the practice of asking students to revisit their work (Bangert-Drowns et al 1991).

When done correctly, feedback can result in students reflecting and rethinking their mathematics, while increasing their effort and motivation.

Providing feedback linked to learning criteria and mathematical goals provides information that is actionable by the student and has been shown to have positive effects on student learning. Conversely, feedback that results in less effort or lowering goals has shown decreases in performance (Kluger and DeNisi 1996). Wiliam (2011) summarizes this idea stating: "feedback functions formatively only if information fed back to the learner is used by the learner to improve performance" (p 120). Effective feedback strategies will cause students to think, rather than react emotionally.

All feedback, whether given as students are working on a task, activity, during classroom discussions or after an assignment is completed, should be focused, causing the student to take action. Comments such as think or try again or good work do not result in increased motivation, therefore, do not often result in increased student achievement.

Activating Students as the Owners of Their Learning

Students must have opportunities to be involved and be responsible for all aspects of their learning. Using such techniques as self-assessment with a provided rubric or student and teacher codeveloped rubric is one way to make learning a shared experience.

Activating Students as Resources for One Another

Many teachers have found that asking students to review, analyze and provide feedback (not grade) another student's work is sometimes easier than analyzing one's own work. Working on this strategy provides a stepping stone to analyzing one's own work more efficiently and effectively.

There are important areas of consideration for implementing the five aforementioned strategies. First, thoughtful and intentional planning for formative assessment begins with a goal for each lesson and determining criteria for success that is clear as to what should be accomplished. Then rich tasks and activities are selected that will engage all students in discussions, while providing opportunities for constructive feedback, and establishing ways for students to monitor their own progress toward the learning goal. Additionally, planning requires revisiting and reworking lesson plans in an effort to implement formative assessment on a more regular basis. Moreover, thoughtful, intentional planning involves developing a lesson that will elicit student thinking in relationship to the mathematical goal.

Also important to implementing the five formative assessment strategies is teacher knowledge of mathematics' learning trajectories also referred to as learning progressions. Studies by Clements et al (2011), Carpenter et al (1989), Clarke (2004) and Clarke et al (2001) have found that professional development focused on the instructional use of learning progressions results in improved student achievement. The findings also suggest that knowledge of learning progressions in the use of formative assessment has the potential to strengthen the interpretation of evidence of student work to inform instruction and learning. (For a brief explanation of learning progressions/trajectories by researcher Douglas Clements, go to www.youtube.com/watch?v=GNBi4xhXevo.)

All strategies and techniques are bound together by the fact that they impact instruction and learning. Although there is not a prescription for where to start and what strategy to use, it is important that formative assessment is part of one's practice. Implementing formative assessment in classrooms works best if teachers start with where they are and move to where they want to be (Leahy et al 2005).

How NCSM and AMTE Members Can Implement Our Position

As leaders, NCSM and AMTE members must work to ensure that preservice and inservice teachers, administrators and other stakeholders in districts and states have knowledge of the research-based practices involved in formative assessment. In order for formative assessment to be intentionally and systematically integrated into classroom instruction, major effort is needed.

Members of NCSM and AMTE are strongly encouraged to provide professional development in the skilful use of formative assessment so that preservice and inservice teachers

- understand how to implement the previously discussed formative assessment strategies;
- use knowledge of the mathematics education research including learning progressions to inform instructional decision making;
- use activities and tasks that elicit student understanding;
- expand and improve questioning and classroom discourse;
- provide opportunities for analysis of student work and instructional decision making;
- implement strategies to engage all students in rich activities, tasks and discussions;
- provide productive oral and written feedback that moves learning forward; and
- incorporate peer and self-assessment opportunities in the classroom.

Additionally, NCSM leaders are strongly encouraged to

- use NCSM's *PRIME Principles and Indicators for Mathematics Education* to guide the work of formative and summative assessment;
- provide ongoing support for teachers as they plan formative assessment within professional learning communities (PLCs);
- assure that facilitators of professional development model the use of formative assessment instructional strategies;
- provide teachers with tools and resources, such as learning progressions and item and lesson banks;
- provide professional development for school administrators in order to

a) create opportunity and time for teachers to meet and collaborate;
b) provide opportunities for teachers to report progress, for example, at staff meetings;
c) incorporate formative assessment into the school improvement plans; and

- ensure that local policies support the implementation of formative assessment and that those policies such as pacing guides and interim assessments do not detract from the effective use of formative assessment.

Additionally, members of AMTE are strongly encouraged to

- assure that preservice teachers have experienced the use of formative assessment by their instructors in preservice classes;
- focus on research that deepens understanding of effective formative assessment practices in mathematics classrooms;
- require preservice teachers to intentionally and systematically incorporate formative assessment in the writing of lesson plans;
- provide preservice and inservice teachers opportunities during clinical experiences to reflect on formative assessment's impact on student learning;
- work with K–12 partners to provide professional development on formative assessment to inservice educators;
- provide support and guidance to school administrators on how best to support teachers as they implement formative assessment in their classrooms;
- provide support and guidance to school administrators on local policies that support the effective use of formative assessment in schools;
- provide tools and resources such as learning progressions and item and lesson banks that support the implementation of research-based formative assessment to preservice and inservice teachers; and
- publish for the purpose of supporting a greater understanding of the effective use of formative assessment.

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Comments from Your Executive

This formative assessment position paper correctly identifies the challenge of bridging research and practice. While most teachers understand that formative assessment is an essential element of classroom practice, many struggle to implement more formative assessment into their math classes. Formative assessment can be embedded directly into lessons so that it is virtually indistinguishable from instruction. When schools ask me to work with them on assessment, the most common request I get is to help them come up with ways to embed formative assessment more seamlessly into their lessons. In Alberta, we are fortunate to have the Alberta Assessment Consortium, whose purpose is to promote good classroom assessment practice. Their website (www.aac.ab.ca) is a great place to start the hunt for formative assessment materials for math classrooms. A study they recently completed looked at formative assessment specifically in high school math classrooms. All the resources developed in that project are on the AAC website.

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