New York State
EDUCATION DEPARTMENT
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Brief 5:

Mathematics Assessment of and for Student Learning

Supporting Evidence-Based P–12 Mathematics Teaching Practice

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Assessment is used to understand students' knowledge and skills both at a particular point in time (e.g., with a single test) and across a period of time (e.g., with pre- and post-tests and summative assessments). Yet in practice, what is assessed, how it is assessed, and how the measurement information is used varies. This brief outlines complementary approaches to assessing students' mathematical knowledge, skills, understanding, and mathematical identity, and the uses of different kinds of information with care.

Assessment of mathematics learning can support students' mathematical development if it is systematic and comprehensive, and if the assessment tools are useful for instruction. It can enable teachers and school systems to implement appropriate instructional approaches and interventions to support students with particular needs. Assessments also make it possible for teachers and school systems to ensure that effective Tier I instruction is taking place and make instructional adjustments as needed. Research shows that a majority of students will show grade-level proficiency on assessments when strong Tier I instruction is in place (Swanson et al., 2017; Shapiro, 2014). Information about instructional practices that are core to Tier I instruction can be found in Briefs #1, #2, #4, and #6.

Systems of Assessment

The New York State Education Department brief *Science of Reading: Leading for Literacy* outlines the requirements of assessment systems to measure student progress and needs. Such systems include screening assessments administered to all students to serve as early identifiers for intervention, diagnostic assessments to support the identification of appropriate interventions for some learners, and specialized diagnostics to understand needs of specific learners, including those with mathematics disabilities such as dyscalculia and general mathematics learning disabilities. Systems of assessment also include classroom, formative, and informal assessments of student progress toward learning goals—the primary focus of this brief.

The Role of Assessment in Advancing Equity

Assessing student mathematics learning can support equitable teaching and learning when it is done thoughtfully. But this takes care. Too often, assessment data are interpreted solely in terms of gaps or deficiencies in student understanding and performance instead of an overall appraisal of what students know and can do and what they need to learn. Effective instruction builds on students' strengths, understanding, and resources to support students' continued growth, and seeing and naming these is vital. Although identifying what students do not know or cannot yet do can be important for identifying students in need of greater support or for identifying patterns in performance (e.g., differences in performance across groups), these analyses can also contribute to the reinforcement of deficit orientations associated with marginalized identities (Aguirre et al., 2024). Awareness of this tendency is important, and steps must be taken to look critically at differences in assessment results.

Questions to Consider

As educators, we want the results of assessments to reflect students' knowledge and skills accurately. However, sometimes biases get in the way. When teachers and leaders notice differences in performance associated with race, gender, language, and socio-economic status, they must interrogate the reasons for differences and determine whether their results are accurate. Some considerations and questions to ask include:

- **What biases might be inherent in the assessment? Are the contexts of problems or tasks impeding students' ability to demonstrate their knowledge? Are there accessibility issues?**
- **Was the assessment aligned with the instruction and instructional goals? In other words, was the assessment assessing what was taught?**
- **Were students supported with opportunities to self-assess, reflect on their learning, and build metacognitive skills?**

When identifying differences in performance, teachers and leaders must consider whether biases in the assessments might have influenced the results, and if so, how to change the assessments to more accurately measure student knowledge and skill. This may involve addressing accessibility issues such as adjusting the context or wording of problems or it may involve adding or removing items to better align with instructional goals. In other cases, when the items themselves do not appear to be the source of performance differences, teachers and leaders must consider shifts in instructional practice to better support student learning (see Brief #4) and whether the curriculum materials provide appropriate support (see Brief #7).

Attention to a broad view of students' strengths is also crucial. This involves examining information about how students are reasoning, the resources on which they are drawing, and the strategies they deploy. While accuracy matters for some elements of mathematical skill, other elements of mathematical competence are crucial to consider. These include mathematical reasoning, interpreting problems, using representations, and care with language. Students' verbal or written responses and drawings reveal important information about what students understand about the mathematical ideas, their skill with explaining their thinking and reasoning, how they make use of available mathematical tools, and their ability to represent their mathematical ideas. Identifying strengths in each of these areas as well as the underlying mathematical conceptual understandings is necessary to support students' continuing mathematical development.

Purposes for Assessment

Teachers deliberately use a variety of methods to assess what students are learning during and after lessons. Some assessments are *of* learning while others are used *for* learning. Assessments *of* learning are assessments that take place after learning has occurred and are called summative assessments. Assessments *for* learning are formative and take place regularly throughout the course of instruction. New York State's Educational Assessment Strategy describes the specific purposes and frequency of typical assessment types, and the questions each type can help you to answer.

Methods and tools for assessing students' mathematical development can take a variety of forms and should be aligned with the purposes for assessing. Among the purposes are:

1. Teacher-led formative assessment: Checking in up close on how students are making sense of instruction. After a lesson or a few, what understanding and skills are students developing and are there aspects that have been confusing that warrant further experience and instruction?

2. Self-appraisal: Supporting students to appraise their own learning. Assessment tasks can provide students opportunities to reflect on what they are doing, what they see themselves developing, and what they want to focus on for their continued development. This information is useful not only for students themselves but also for teachers to gain a view of how students appraise their own levels of understanding, skill, and mathematical confidence.

3. Assessment of mathematical identity: Learning how students see themselves as mathematical thinkers and knowers, focused on the development of their mathematical identity. This is an important aspect of their growth, for when students see themselves as capable, this supports engagement and identification with mathematics, both of which are goals of mathematics education. That so many adults do not see themselves as "math people" is an outcome that we should seek to change for this generation.

4. Summative assessment: Documenting what students have learned after completing a specific unit of instruction, what they may need further support with, and what they can extend beyond the scope of what was taught. This information provides insight about how students have taken up instruction and can contribute to adjustments in teaching and curriculum for a particular set of mathematical concepts, skills, and practices.

5. Standardized assessment (state, national, and international assessments): Using common rigorously developed assessment items that enable analyses at scale, including comparisons, changes over time, and connections to instructional approaches, curriculum, teachers, and other critical variables that affect learning. State assessments are required by federal law to measure student progress toward state learning standards with the goal of fostering educational equity across the state. National and international assessments provide information about patterns in collective student learning. These assessments allow for comparison across states and countries and the examination of trends in mathematics learning over time.

The remainder of this brief focuses mainly on formative and informal assessments as these are used daily by teachers to understand whether instruction needs adjustment, what supports may need to be put into place, how students are understanding themselves and their learning, and how they are making sense of new topics.

Assessments *for* Learning

Assessments *for* learning provide frequent opportunities for teachers and students to monitor and learn about their mathematical learning. These assessments take place during the course of everyday teaching and learning and are an inherent part of several high-leverage instructional practices such as eliciting student thinking, setting up and monitoring small group work, and leading a discussion (see Brief #4). They may be informal verbal techniques, structured opportunities for all students to share their thinking, or opportunities for students to assess their own progress and can include entrance routines and exit tickets. Next, we share examples of different types of assessments for learning.

Ideas and Resources

Looking for ideas and resources that are mathematics specific? Check out the following:

- *The Formative 5: Everyday Assessment Techniques for Every Math Classroom*, by Francis (Skip) Fennell, Beth McCord Kobett, and Jonathan A. Wray. A free webinar related to the book can be found online here.
- *Mathematics Formative Assessment: 75 Practical Strategies for Linking Assessment, Instruction, and Learning,* by Page Keeley and Cheryl Rose Tobey. Free resources related to the book can be found on Page Keeley's website.

Teacher-led formative assessments

These include exit tickets, short quizzes, journal writing, tasks matched to what was done in class, or tasks that slightly extend what was done in class.

Formative assessment data support teachers in determining whether instruction is supporting student learning and how to proceed with the next lesson or series of lessons. If the data gathered from a lesson show that very few students understood the content, the teacher may decide to reteach the content using an alternative activity and/or different instructional strategies. If all students understood the content, the teacher may decide to increase the cognitive demand of the next lesson, anticipating that students are ready for more challenge. If the data show that a small group of students needs support with the content or that there are several differing support needs, a teacher may decide to engage in small group instruction.

Spotlight on Practice

Example of an exit ticket after work in class on properties of the number line

1. Is A less than or more than H? How do you know?

2. Is A less than or more than X? How do you know?

3. Label what numbers go at A, X, M, and H. Then, explain how you know what M is.

Other examples of formative assessments for learning include asking students to:

- Restate something or explain something to the whole class
- Critique or comment on an idea (e.g., a piece of student work or a strategy to solve a problem)
- Contribute one idea or takeaway from the lesson
- Write about something they learned (e.g., in their notebooks)
- Complete a problem that reflects the material covered in class but is new (e.g., a new problem or new text)
- Respond in writing to another's idea or claim
- Indicate in writing something they did well and something that was hard for them

Affordances and Limitations: Teacher-Led Formative Assessments

Affordances: Provide information close to instruction of how students are understanding what was worked on in class; can help to calibrate instruction to what students are taking up, and support students to reflect on their own learning; provide teachers with information about how students are seeing their progress.

Limitations: Questions must be well designed to get useful information, and if the questions are too close to exactly what was done in class or too different from it, the information gained might be misleading. Students might not be used to being asked to reflect on their learning and might need some experience and support to learn to do this.

Self-appraisal

These include exit tickets, questions as part of homework assignments, short surveys.

Self-appraisal helps students to reflect on their own learning and progress. While this can serve to give ownership of learning to students, it can also help teachers to understand what specifically students are finding more or less difficult, whether students need individual support, and which students may need scaffolds to assess their own learning. This information can help teachers to design upcoming lessons and to build additional metacognitive moments into their teaching as needed.

Spotlight on Practice

Example of a self-appraisal

Please look back over your work. Remember to write complete answers to these questions.

What was the hardest question on the homework? Why?

_____

_____

What was the easiest? Why?

_____

_____

Which one or ones was the most interesting to you? What made it interesting?

_____

_____

Assessments of mathematical identity

These include short questionnaires, drawings, journal entry prompts.

Spotlight on Practice

Examples of assessments focused on mathematical identity

DO YOU MOSTLY AGREE OR DISAGREE WITH THESE STATEMENTS?

Explain why or give an example.

1. I think of myself as good at math.
2. When a math problem is hard, I think I won't be able to do it.
3. I am not a math person.
4. I can help other people with math.
5. I enjoy learning math most of the time.
6. I am good at solving math problems in everyday life.
7. I avoid doing math.

Draw a picture of yourself doing math. What does it show about you?

Affordances and Limitations: Self-Appraisal

Affordances: Broaden assessment to include data on how students are seeing themselves as mathematical thinkers and doers; signal that this is an important goal of mathematics instruction.

Limitations: Students might not be used to being asked to reflect on their learning and might need some experience and support to learn to do this; questions must be well designed to get useful information.

Task-based assessments

Mathematics is not simply following procedures to produce numeric solutions, so problems that focus only on procedures and answers limit the information that can be gained about students' mathematical development. Mathematics also requires problem-solving, explanation, justification, representation, and selection of mathematical tools. Many mathematical problems and situations that require mathematical analyses and reasoning have more than one solution. Assessments should include tasks that have different solution spaces:

- unique (single) answers;
- multiple but finite solutions (and justifying that all solutions have been found);
- infinitely many solutions; and
- no solutions (impossible) problems.

An appropriately full portrait of students' mathematical development is difficult to capture if mathematics assessments do not include tasks that require these skills.

Assessing what mathematical competence actually involves means utilizing tasks that require students to demonstrate these skills in order to solve them. Such tasks are difficult to design, but there are resources available to help. For more than 30 years, international researchers at the Mathematics Assessment Resource Service have designed, researched, and made available such tasks through the Mathematics Assessment Project. Resources are also available through Inside Mathematics which hosts a variety of resources, including performance tasks and non-routine problem solving tasks.

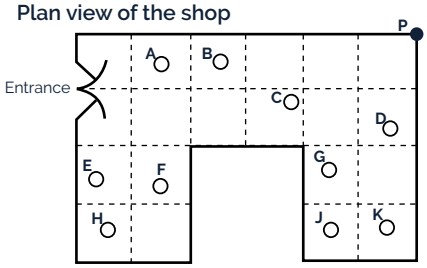
Spotlight on Practice

Example of a task-based assessment

This annotated high school example illustrates how one task can be structured to call upon a number of different mathematical skills:

A shop owner wants to prevent shoplifting. He decides to install a security camera on the ceiling of his shop. The camera can turn right round through 360°. The shop owner places the camera at point P, in the corner of the shop.

Plan view of the shop



1. The plan shows ten people who are standing in the shop. These are labelled A, B, C, D, E, F, G, H, J, K. Which people cannot be seen by the camera at P? Tell how you know.

2. The shopkeeper says that "15% of the shop is hidden from the camera." Show clearly that he is right.

3. Show the best place for the camera, so that the it can see as much of the shop as possible. Explain how you know that this is the best place.

Mathematics Assessment Project, 2011

Key Take-Aways

1. Assessment of students' mathematical development is essential for instruction that is aligned with students' strengths, needs, and trajectories.

2. Different kinds and tools for assessment serve different purposes and a strong system for attending to students' development includes multiple types of assessments. These should include deliberate attention to high-leverage content and practices (see Brief #3) and mathematical identities.

3. Regularly assessing students' understanding can help to attune instruction and learning experiences to students' development. Summative assessment can provide information about what students have taken up and mastered.

4. To advance equity and disrupt problematic deficit orientations to students' competence, there must be careful analyses of the tools used and potential biases they may hold.

Key References

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