4

MOVING FROM ASSESSING WHAT STUDENTS KNOW TO ELICITING HOW STUDENTS UNDERSTAND

Instead of using technology as a tool for assessment *of* math learning, what if we leverage technology as a tool to assess *for* learning?

THIS CHAPTER describes two kindergarten classes where students are learning about shapes. Both cases include technology in the lessons; note how the use of technology supports the teaching of math. At the beginning of each case, take a look at the ISTE Standards and math standards in your state to see how the two cases align with these expectations; later you can compare with the alignment at the end of the chapter. Once you have read and reflected on the two cases, read what research has to say about two big ideas: ***Technology as an Assessment Tool*** and ***Leveraging Students' Mathematical Understanding;*** consider how that connects with what you noticed. Finally, consider the recommendations for practice as you connect the research and the case studies with your own classroom.

Technology as an Assessment Tool

The U.S. Department of Education's Office of Educational Technology sets the goal: *At all levels, our education system will leverage the power of technology to measure what matters and use assessment data to improve learning.* Assessment helps us measure and respond to what students do and do not understand. Technology can allow us to do so more efficiently. From the early days of Scantron machines that enabled quick scoring of multiple-choice assessment items to computerized adaptive assessment, technology continues to provide increasingly sophisticated assessment tools. Many online programs now offer instantaneous feedback for students and voluminous amounts of assessment data on teacher dashboards. Although these summative measures can be helpful for many purposes, it is also important to acknowledge the potential of technology to formatively assess students to inform more in-the-moment decision-making. Using technology can reveal more nuanced information about how students understand math, enabling more responsive teaching and meaningful learning.

Leveraging Students' Mathematical Understanding

Assessment is more than grading how many answers students get right and wrong. Good classroom assessment practices elicit students' mathematical understanding—math they know and how they know it. Posing questions that elicit common misconceptions or reasoning strategies and providing students with opportunities to demonstrate their understanding in a variety of ways allows teachers better access to interpret and leverage student thinking. Technology can be a useful tool for making student thinking more visible. Once teachers have a better sense of what students know, they can adapt math instruction to more equitably improve learning.

Mr. Evers's kindergarten class is learning to identify two-dimensional shapes. He integrates technology into the lesson as a way to assess student work. As you read the following case, consider the effectiveness of technology and assessment practices during the lesson.

CASE 4.1

Mr. Evers's Kindergarten Identifying Shapes Lesson

OBJECTIVES

- Recognize equivalent fractions using a variety of representations.

Mr. Evers is teaching a lesson about shape identification to his kindergarten class. He knows that some kids already know most, or all, of the shape names. His challenge will be to keep those kids engaged in a lesson that also addresses the needs of students who are still learning shapes and shape names. He decides to use an online video to introduce shapes and shape names. The video includes a song and game in which a shape is displayed on the screen. The name of the shape is stated out loud and written on the screen. Students sing and dance along to a shape name game/song. The shapes in the video include circle, triangle, rectangle, square, oval, and rhombus.

After the shape sing- and dance-along, Mr. Evers projects the Pattern Shapes virtual manipulative from Math Learning Center (apps.mathlearningcenter.org/pattern-shapes) from his iPad onto the whiteboard. He chooses an outline of a turtle for students to fill in using pattern block shapes, as shown in Figure 4.1.

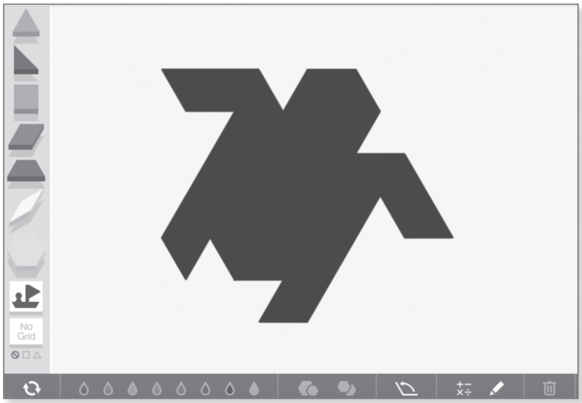

Figure 4.1 Pattern block turtle outline.

He chooses sticks with students' names to randomly call on students. Students take turns going to the iPad, dragging one shape, and placing it onto the turtle. With each shape, Mr. Evers asks the class to identify the name of the shape. Because it was not in the video, he tells students that the red shape is called a trapezoid. Eventually, the class fills in the turtle shape with a variety of pattern blocks (shown in Figure 4.2).

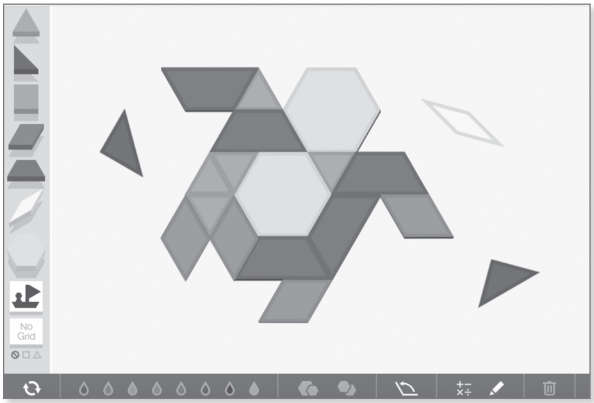

Figure 4.2 Completed pattern block turtle.

Mr. Evers divides students into three groups and finishes the class with station rotations. He wants to assess how well students can identify shapes on their own. In one station, students work on class computers to complete the online IXL Kindergarten skill assessment, Name the two-dimensional shape (ixl.com/math/kindergarten/name-the-two-dimensional-shape). Once logged in (a previously-developed routine in the classroom), students can read the words on the screen or press the speaker to hear the directions, as shown in Figure 4.3.

The website gives students immediate feedback as to the correctness of their answers. It keeps track of the number of questions answered, time elapsed, and a score. Mr. Evers can refer back to the assessment data to get a sense of students' progress in the lesson. While a third of the students take online assessments, another third work at their desks coloring shapes and tracing the names of each shape on a workbook page. The rest of the students use physical pattern blocks to trace shapes and draw a picture. All students have an opportunity to rotate to each of the three stations. This approach keeps students engaged and enables Mr. Evers to use online individual assessment, even though he only has a few classroom computers. When he reviews the assessment data, he's happy to see that students performed very well at identifying shapes.

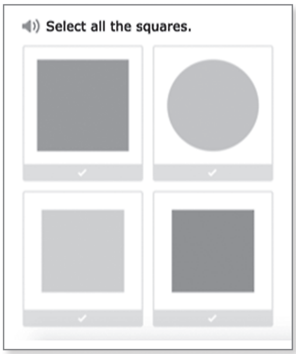

Figure 4.3 IXL shape question.

The next day, as a warm-up, Mr. Evers has students complete a workbook page on which they color various types of shapes in different colors. Because the assessment results from the previous day were quite positive, he is discouraged to see that many students are not correctly identifying some of the triangles, squares, and rectangles. He will spend time today reteaching about identifying shapes.

Reflection Questions

First consider Mr. Evers's use of technology in this lesson. He selected technologies to keep his students engaged in learning about his lesson objectives.

- Would you consider this a technology-rich lesson? Why or why not?
- What was the purpose of Mr. Evers's technology use in this lesson?
- How did Mr. Evers's integration of technology advance the teaching and learning of math in this lesson?
- What were he and/or the students able to do with technology that was different from or better than what could have been done without technology?
- How did Mr. Evers use technology as an assessment tool?

Now, consider the math teaching practices in Mr. Evers's lesson.

- What were Mr. Evers's math goals for this lesson?
- To what extent did students have equitable access to learn and demonstrate their understanding in this lesson?
- Overall, what strengths do you see in this lesson? What opportunities do you notice?
- How did Mr. Evers elicit and build upon students' mathematical thinking?
- Why do you think some students had trouble identifying triangles, squares, and rectangles, even though they performed well on the previous day's assessment?

Ms. Jennings's kindergarten class is also learning about identifying shapes. As you read about Ms. Jennings's lesson, consider how she integrates technology into the lesson and her math teaching practices. How does she use technology as an assessment tool? To what extent does she leverage students' understanding to improve learning in the lesson?

CASE 4.2

Ms. Jennings's Kindergarten Identifying Shapes Lesson

OBJECTIVES

- Identify two-dimensional shapes.

Ms. Jennings's kindergarten class will be learning to identify shapes in today's class. Nearly all of her students can identify basic shapes such as circles and squares, but she expects other shapes to be new for most of the kids. Ms. Jennings has used Google Slides and Pear Deck to prepare an interactive slideshow. She will project her slides onto the whiteboard, and students will share iPads to interact with some of the slides she's prepared.

Students in Ms. Jennings's class are seated in pods, or desks placed in groups of four. At the beginning of class, she gives each group an iPad, preloaded with the activity she'll have them use during the lesson. The children are accustomed to using an iPad during class and, because there are only a limited number of devices, they are also accustomed to working cooperatively on the iPads. They have previously developed routines for accessing apps and logging in to frequently used programs.

She begins the class by showing a slide with four shapes. Ms. Jennings asks students to open their iPad and talk with others in their group about the names of the shapes they see. After a couple of minutes, she asks students to share their ideas about the shapes. All groups were able to accurately identify the square, rectangle, and triangle. Some students didn't know the name for the hexagon, or called it a "stop sign," or octagon, instead. She showed the names of each shape so students could see the shape, hear the spoken name of the shape, and see the written word (see Figure 4.4).

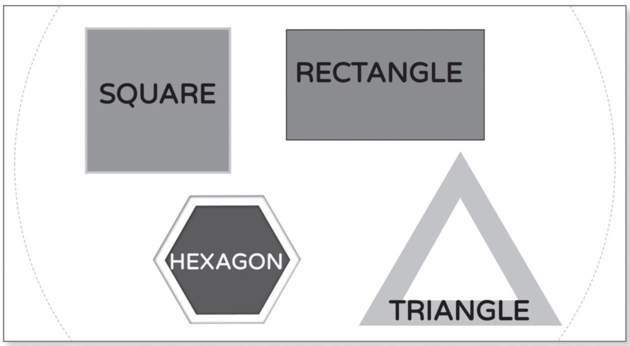

Figure 4.4 Four shapes.

Ms. Jennings points at the triangle and asks students how they know it is a triangle. Student responses include, "It has three sides," and, "It points up." She leads the class in counting the number of sides on the hexagon, showing that hexagons have six sides. She asks students to discuss the difference between a square and rectangle. Students conclude that both squares and rectangles have four sides and four corners. They notice that the square's sides are all the same size, but the rectangle has two long sides, and two short sides. Although these are not precise mathematical definitions, Ms. Jennings decides they are adequate working definitions at this level.

Ms. Jennings knows that young children sometimes have difficulty recognizing different versions of shapes. She knows this is relevant to her students because she just heard a student say a triangle "points up." To elicit and address these misconceptions, she shows the interactive slide shown in Figure 4.5, and asks students to circle all of the triangles and draw an X through all of the rectangles.

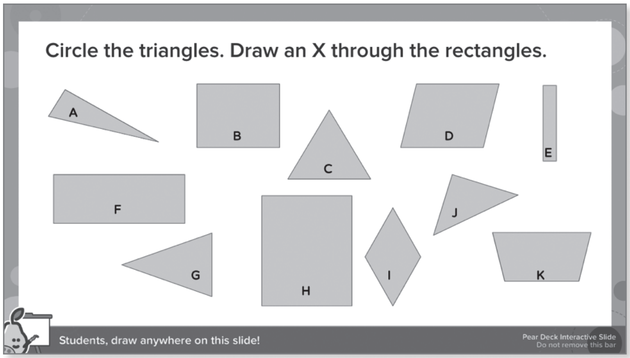

Figure 4.5 Identifying triangles and rectangles.

As expected, all student groups identify shape C as a triangle, and shape F as a rectangle. Few student groups identified shape A or J as triangles, or shape E as a rectangle. By drawing out these common misconceptions, Ms. Jennings is able to address them with the whole class. She advances to the next slide (shown in Figure 4.6), which links directly to the Pattern Shapes virtual manipulative from Math Learning Center (apps.mathlearningcenter.org/pattern-shapes). The students identify the pattern block shapes they recognize (triangles, square, hexagon). Ms. Jennings leads a discussion about triangles and squares. She writes the shape names and shows the corresponding pattern blocks. Students agree that even when she moves the shapes or makes them a different size, they are still triangles and squares. She then introduces two new shapes: rhombus and trapezoid.

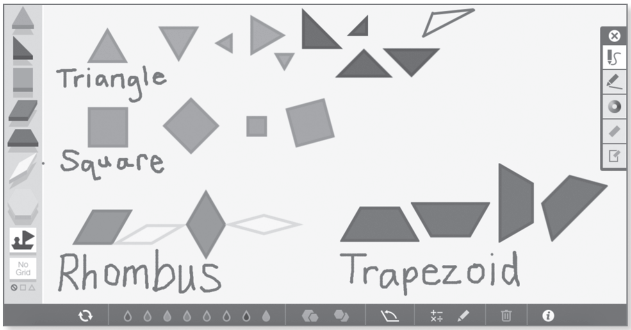

Figure 4.6 Identifying pattern block shapes.

To check for understanding, Ms. Jennings advances to the next slide (Figure 4.7), which is interactive. Student screens now show five shapes and five shape names. The directions for the slide are to draw lines between each shape and its corresponding name. Because the children are beginning readers, Ms. Jennings reminds them they can press the speaker to hear each word out loud.

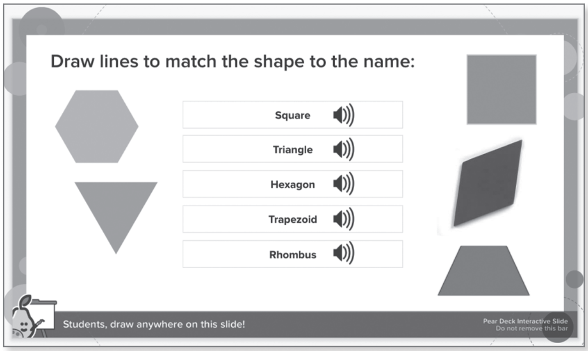

Figure 4.7 Matching pattern block images and shape names.

Ms. Jennings can see students' work on her screen and notices that several groups have confused trapezoid and rhombus, the two newest, least-familiar shapes for students. Before starting the next activity, they review the shape names again, starting with trapezoid and rhombus. Then, Ms. Jennings uses the Pattern Shapes app to model what it looks like to create a shape with pattern blocks, and then passes out sets of physical pattern blocks to each table. At this point, she wants students to work with the physical pattern blocks because they are easier for young children to manipulate.

She tells students to each create a picture with the blocks, and then tell their group members the names of the shapes they used. As she circulates around the room, she takes pictures of student work so she can recreate their pictures in the app and discuss as a whole class. She reproduces and projects Gwen's pattern block picture, (as shown in Figure 4.8). Ms. Jennings asks Gwen to tell the class about her picture.

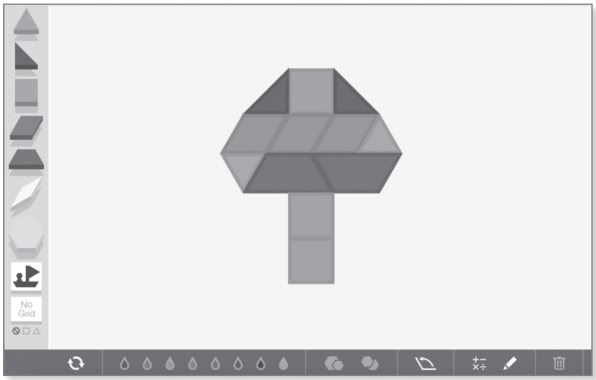

Figure 4.8 Gwen's pattern block tree.

Gwen explains, "I made a tree with the blocks." When asked about the shapes she used to make her tree, Gwen replies, "…with some help I used orange squares, green and purple triangles, blue rhombuses, and red trapezoids." Ms. Jennings points at shapes that are turned in different directions, reinforcing that their orientation does not change their shape.

After learning about shape names and exploring with the pattern blocks, Ms. Jennings concludes the lesson with a rotation activity. She divides the class into three groups. One group goes to a table in the back of the room to work directly with Ms. Jennings on creating shape drawings. This enables her to ask questions to individual students, and get a more in-depth sense of each student's understanding. Another group of students completes a workbook page on naming shapes. They color a shape and trace the name of the shape below it. The third group completes wooden shape puzzles. The fourth group works on the iPads to answer seven "Name Shape 3" practice exercises from Khan Academy. The exercises include squares, rectangles, hexagons, circles, rhombuses, triangles, and trapezoids—all in various orientations. Fortunately, Ms. Jennings has a teacher aide in the classroom to help monitor students' work at the different rotations, and to get students started with the iPad practice exercises.

All students have a chance to rotate through each of the activities, giving each a chance to demonstrate their understanding in a variety of ways. Ms. Jennings is able to assess students' understanding through the small group work, workbook pages, and data provided by Khan Academy.

Reflection Questions

Now that you've read about Ms. Jennings's lesson, consider her technology use. She selected technologies to engage and assess her students.

- Would you consider this a technology-rich lesson? Why or why not?
- What was the specific purpose of Ms. Jennings's technology use in this lesson?
- How did Ms. Jennings's integration of technology advance the teaching and learning of math in this lesson?
- What were she and/or the students able to do with technology that was different from or better than what could have been done without technology?
- How did Ms. Jennings use technology as an assessment tool?

Now, consider the math teaching practices in her lesson.

- What were Ms. Jennings's goals for this math lesson?
- To what extent did students have equitable access to learn and demonstrate their understanding in this lesson?
- Overall, what strengths do you see in this lesson? What opportunities do you notice?
- How did Ms. Jennings elicit and build upon students' mathematical thinking?

What Does the Research Say?

The following research supports the use of technology as an assessment tool:

- The U.S. Department of Education's Office of Educational Technology suggests that the transition from pencil–paper to digital assessments will enable a number of shifts. The shifts that technology makes possible include embedding assessment within, instead of after, learning;

incorporating universal design principles for increased accessibility; enabling adaptive rather than fixed assessment pathways; providing real-time machine feedback rather than delayed teacher feedback; and allowing multimedia assessment items rather than generic multiple choice.

- Technology provides assessment data that was previously inaccessible to educators, parents, and students. In fact, technology has given rise to entirely new fields such as learning analytics and data mining. Many programs now offer teachers (and parents or students) dashboards of data summarizing potentially relevant assessment information in a single snapshot. However, leveraging voluminous amounts of data requires expanded data literacy on the part of teachers. "Big data" has also given rise to new ethical concerns about privacy. Nevertheless, studies indicate that making assessment data more accessible to teachers can lead to better differentiation for students' individual needs and more responsive teaching. Using technology as an assessment tool offers affordances and emerging challenges for educators, and new questions for researchers.

- Assessment is an ongoing focus in K–12 education, and technology plays an increasing role. The use of technology as a high-stakes assessment tool makes voluminous amounts of data available for analysis and data-driven decision making. This has coincided with high-stakes assessment policy requirements since the 2001 No Child Left Behind Act. Many schools and states are transitioning to computer-based high-stakes assessments in math.

- Computer-based testing affords greater efficiency for schools and stakeholders. On the other hand, it can exacerbate inequities that already exist with regard to high-stakes testing. In order to implement computer-based testing, schools must have access to hardware, software, and digital infrastructure for all students. Computer-based tests must also attend to the needs of bilingual learners and special education populations.

The following research addresses leveraging students' mathematical understanding:

- Although high-stakes, summative assessment has driven policy in math education, much research has focused on formative classroom assessment. The National Mathematics Advisory Panel (2008) found that, "…teachers' regular use of formative assessment improves their students' learning" (p. xxiii). A positive association between formative assessment and improved student learning outcomes has been documented in multiple studies (e.g., Black & Wiliam, 1998a, 1998b; Hattie, 2009; Popham, 2008). Whereas summative assessments measure students' learning of math, formative assessments focus on data and feedback for learning. By eliciting what students know and can do during a lesson, teachers can make instructional decisions to adapt and better address students' learning needs (Leahy, Lyon, Thompson, & William, 2005; Wiliam, 2011).

- Eliciting and interpreting students' mathematical thinking enables teachers to appropriately respond and build upon student ideas. Multiple studies in math education focus on professional noticing of children's mathematical thinking which includes: "a) attending to children's strategies, (b) interpreting children's understandings, and (c) deciding how to respond on the basis of children's understandings" (Jacobs, Lamb, & Philipp, 2010, p. 169). What teachers notice and attend to can have a significant impact on students' learning experiences.
- Assessing math learning means more than determining if answers are right or wrong. Recognizing misconceptions, error patterns, and difficulties enables teachers to diagnose and address incorrect or incomplete ideas early, before students practice and internalize them (e.g., NCTM, 2014; Schifter, 2001; Swan, 2001). To do so, teachers can design questions and tasks that purposefully elicit common errors and misconceptions (e.g., Bray, 2013; Swan, 2001). Incorporating a variety of assessment strategies also gives students an opportunity to demonstrate what and how they know, not just whether their answer is correct or not. Integrating formative assessment that notices and attends to student reasoning, including misconceptions, is a crucial component of effective math teaching practices.

Reflecting on Technology in Math Teaching

As you read the cases of Mr. Evers's and Ms. Jennings's kindergarten classrooms, you may have noticed several similarities and differences. Some of the big ideas are summarized in Table 4.1.

A possible perspective for comparing Mr. Evers and Ms. Jennings's technology use in these lessons might be to ask, *"How is technology used to assess students' mathematical understanding?"* Both teachers used technology in multiple ways throughout the lesson. Although Mr. Evers leverages shared student devices for individual online assessments at the end of the lesson, Ms. Jennings incorporates formative assessment in interactive slides as well as individual online assessment on devices at the end of the lesson. She designed tasks to elicit students' misconceptions about shapes and orientation, addressed those misconceptions through an activity that involved manipulative shapes, and continued to assess students' understanding of shapes in a variety of ways at the end of the lesson. Mr. Evers used assessment as a way to gauge what students had learned, whereas Ms. Jennings used assessment as a way to guide and inform her teaching and, in turn, what students were learning successfully.

TABLE 4.1 Use of Technology in the Cases of Mr. Evers and Ms. Jennings

	The Case of Mr. Evers	The Case of Ms. Jennings
What technology is used?	Teacher iPad and projector, shared student computers, virtual manipulative, IXL practice exercises online	Teacher computer and projector, shared student iPads, virtual manipulative, Khan Academy practice exercises online
What math is emphasized?	Identifying various types of 2D shapes.	Identifying various types of 2D shapes.
How is the lesson launched?	Mr. Evers shows a sing-and-dance-along video about shapes to begin the lesson.	Ms. Jennings displays a slide with four shapes and the class discusses the shape names.
Who is doing the math in this lesson?	Students identify shapes and work in a whole-group setting to create shapes using virtual pattern blocks. Students work individually on shape identification activities and an online assessment.	Students work in groups to identify shapes. They individually create shape drawings with physical pattern blocks and discuss the shape names in small groups. Students also work individually on shape identification activities and an online assessment.
When and how is technology used in the lesson?	The beginning of the lesson is conveyed with a projected teacher device. The end of the lesson includes computers as one of three rotations.	The beginning of the lesson is conveyed through interactive slides using a teacher device and shared student iPads. The end of the lesson includes iPads used for individual assessment in one of four rotations.

We can also examine how technology contributed to equitable math learning experiences for all children in each class. Both lessons enabled students to participate in math discussion with the whole group and in small groups. Furthermore, all students in both classes had an opportunity to interact with technology. Ms. Jennings's lesson included audio options for early readers and physical manipulatives that would be more accessible to students with vision impairments. Ms. Jennings's varied forms of assessment at the end of the lesson enabled each student to demonstrate their understanding in multiple ways.

Recommendations for Practice

This chapter began with the question: *Instead of using technology as a tool for assessment of mathematical learning, what if we leverage technology as a tool to assess for learning?* Classroom cases of Mr. Evers and Ms. Jennings address this question. Whereas Mr. Evers uses technology-based assessment to find out what students do or don't know, Ms. Jennings leverages technology for formative assessment to reveal misconceptions and to inform her teaching during the lesson. Here are three practical suggestions for using technology as both a formative and summative assessment tool in your classroom.

1. Use technology to elicit what students know and understand during a lesson.

Interactive features through tools such as Pear Deck and Desmos allow teachers to pose strategic questions and gauge student understanding within lessons. Other tools include clicker devices (or apps) and the Plickers app through which a single teacher device can quickly summarize responses from cards that students display. Both options allow teachers to pose multiple-choice questions and quickly display summaries of students' responses. Such options are anonymous, and can be used to highlight common misconceptions in a way that might be more comfortable for students and teachers who are just beginning to leverage errors as part of learning.

2. Use technology to document not only students' products, but also their processes.

Ms. Jennings used photos to capture students' pattern block creations and recreated them using a virtual manipulative. (She could also have just displayed the photo images.) You can capture students' authentic work and display it for class discussion using technologies common in many classrooms, (e.g., document camera, cell phone/tablet/camera, scanner, and screenshots). Using technology to document student work opens new possibilities for how students could show their work, potentially incorporating physical or virtual manipulatives, drawings, or visual models. In this way, teachers can rely on a broader array of evidence when assessing student work.

In addition to tools that capture the results of student work, technology also offers exciting opportunities to capture strategies and processes. Screencasting tools allow students to record their voice and writing as they solve problems. Video and audio tools can be used in a similar fashion. In a classroom with many students and only one teacher, technology tools can provide a window into students' mathematical thought processes that might otherwise be accessible only through one-on-one interactions.

3. Use data conveyed in teacher dashboards to inform your instruction.

Many popular platforms such as IXL, Khan Academy, and curriculum-based digital resources provide voluminous amounts of student assessment data on teacher dashboards. Take a closer look at what this data tells you about student understanding. Besides how many exercises students get right or wrong, are multiple students Ms.ing the same question or giving the same incorrect answer? If so, this could indicate a shared misconception. Are some students getting perfect scores but only by taking many attempts? This could be a sign that students are using immediate feedback to guess until they get problems correct, regardless of their actual understanding. Are some students correctly finishing all of their exercises in no time? Consider more appropriately challenging material. Learning to effectively use teacher dashboard data to inform your teaching is a way that technology can support assessment for learning.

Connecting Cases with Standards

In this chapter, the cases of Mr. Evers and Ms. Jennings illustrate two approaches to technology-enabled assessment during a lesson on identifying shapes. The standards identified below indicate alignment with Common Core State Standards for Mathematics, and ISTE Standards for Students and for Educators. You might also consider alignment with math standards in your state or district, as well as ISTE Standards for Administrators and for Coaches.

Math Content Standards

CCSS.MATH.CONTENT.K.G.A.2. Correctly name shapes regardless of their orientations or overall size.

CCSS.MATH.CONTENT.K.G.B.4. Analyze and compare two- and three-dimensional shapes in different sizes and orientations, using informal language to describe their similarities, differences, parts (e.g., number of sides and vertices/"corners") and other attributes (e.g., having sides of equal length).

Mathematical Practice Standards

- Use appropriate tools strategically
- Attend to precision
- Look for and make use of structure

ISTE Standards for Educators

5a. Use technologies to create, adapt and personalize learning experiences that foster independent learning and accommodate learner differences and needs.

5b. Design authentic learning activities that align with content area standards and use digital tools and resources to maximize learning.

5c. Explore and apply instructional design principles to create innovative digital learning environments that engage and support active, deep learning.

6a. Foster a culture where students take ownership of their learning goals and outcomes in both independent and group settings.

6b. Manage the use of technology and student learning strategies in digital platforms, virtual environments, hands-on makerspaces or in the field.

6d. Model and nurture creativity and creative expression to communicate ideas, knowledge or connections.

7a. Provide alternative ways for students to demonstrate competency and reflect on their learning using technology.

7b. Use technology to design and implement a variety of formative and summative assessments that accommodate learner needs, provide timely feedback to students and inform instruction.

7c. Use assessment data to guide progress and communicate with students, parents and education stakeholders to build student self-direction.

ISTE Standards for Students

1c. Students use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways.

6c. Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.