What do they understand?

Using technology to facilitate formative assessment


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Formative assessment is so important to inform teachers' planning. A discussion of the benefits of using technology to facilitate formative assessment explains how four primary school teachers adopted three different apps to make their formative assessment more meaningful and useful.

As teachers, we know the important role that assessment plays in our job. Too often, assessment is seen primarily in terms of summative assessments for the purpose of evaluating student progress or assigning grades. This view limits the potential for assessment to inform teaching and learning—known by many as formative assessment. In fact, a significant amount of evidence has shown the power of formative assessment in raising student achievement (Black & Wiliam, 1998). Some have even claimed that effective implementation of formative assessment can improve student achievement as much as any other instructional intervention (Banks et al., 2005).

The importance of assessment to inform instruction has long been recognised by the National Council of Teachers of Mathematics (NCTM) and the community of mathematics educators. Both the *Assessment Standards for School Mathematics* (NCTM, 1995) and *Principles and Standards for School Mathematics* (NCTM, 2000) asserted that assessment should support mathematics learning and inform instruction. As stated more recently in *Principles to Actions*, "effective mathematics teaching elicits evidence of students' current mathematical understanding and uses it as the basis for making instructional decisions" (NCTM, 2014, p.53). The importance of assessment is also reflected in the AAMT Standards (AAMT, 2006) where excellent teachers are described as using a wide variety of assessment strategies that continually gather evidence of student learning and use that data to inform instruction and provide feedback to students. In the mathematics classroom, formative assessments that gather such critical information are both informal and formal (e.g. pre-assessments, questioning, classroom discussions, exit tickets, mathematics journals, etc.). The bottom line is that formative assessment requires that teachers are eliciting students' mathematical understanding and using that data to inform instruction and support student progress towards learning goals.

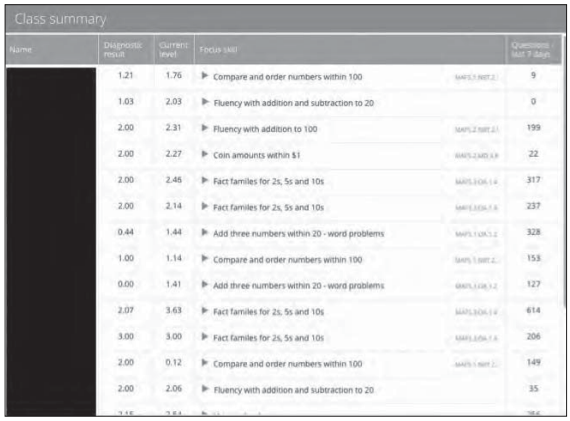
So how can we ensure formative assessment is used more frequently? One significant barrier for many teachers is simply envisioning how to fit formative assessment into a day that already feels like a time-crunch (Cizek, 2010). To be able to harness the power of formative assessments in the classroom, it seems vital that teachers find simple ways to integrate it into their daily mathematics teaching. This article shares how four primary teachers embraced the possibilities that technology provided for implementing formative assessment effectively and efficiently. The teachers featured in this article teach second and third grade in a primary public school in the United States, which recently received classroom sets of iPads. This article presents the iPad apps that these teachers used regularly during their mathematics instruction to facilitate formative assessment, the kinds of information they were able to elicit, how they adapted their instruction, and considerations for teachers hoping to implement similar technology.

Using technology to elicit students' mathematical understanding

What these classroom teachers discovered was that technology was an avenue for eliciting individual student mathematical understanding in a way that could not be done efficiently in a room of 18 to 24 primary students. In their classrooms, the availability of tablets opened up opportunities to engage students in formative assessment without disrupting the class. Teachers could now ask students to log in during mathematics centres[1], when they finished an assignment early, during class or small group work, or even before or after school.

Once students established a routine for working on tablets, teachers felt free to move around more during instruction, provide more individual feedback, and identify and address misconceptions as they were happening.

With technology effectively integrated in their classrooms, teachers were able to gather different representations of student understanding. For example, one teacher found the use of apps that track student progress and make that data readily available, very helpful in understanding where students were in the mastery of basic skills. *Sum Dog*, one of many similar apps, provided engaging games meant to measure basic fact fluency. Tablet apps like *Sum Dog* provided the teacher with opportunities to monitor student progress and to "set specific skills for each student as well as print out reports [for parents]". The class summary shown in Figure 1 is one way that this teacher can see the individual learning goal she set for each student as well as their progress since their initial diagnostic results. Students can also view their results, giving them the opportunity to monitor their own progression towards established learning goals and engage with their teacher on ways to improve the understanding. In line with the first mathematics teaching practice from *Principles to Action*, this app supports teacher clarification of learning goals for students based on learning progressions that can inform future instructional decisions (NCTM, 2014). In addition, this teacher notes how engaged students are with this app and that "it is as much motivation as it is meeting the specific needs of each student."


Class summary

Name	Diagnostic result	Current level	Focus skill		Questions last 7 days
[redacted]	1.21	1.76	Compare and order numbers within 100		9
	1.03	2.03	Fluency with addition and subtraction to 20		0
	2.00	2.31	Fluency with addition to 100		199
	2.00	2.27	Coin amounts within $1		22
	2.00	2.46	Fact familes for 2s, 5s and 10s		317
	2.00	2.14	Fact familes for 2s, 5s and 10s		237
	0.44	1.44	Add three numbers within 20 - word problems		328
	1.00	1.14	Compare and order numbers within 100		153
	0.00	1.41	Add three numbers within 20 - word problems		127
	2.07	3.63	Fact familes for 2s, 5s and 10s		614
	3.00	3.00	Fact familes for 2s, 5s and 10s		206
	2.00	0.12	Compare and order numbers within 100		149
	2.00	2.06	Fluency with addition and subtraction to 20		35

Figure 1. Teachers can view reports on student progress that include initial results compared to current levels of understanding for individualised learning goals.

Another teacher was able to elicit student understanding of more complex mathematical concepts through the use of an interactive whiteboard app, called *Show Me*. Teachers can use the app to uncover student understanding in multiple ways—again, addressing the *Principles to Action* mathematical teaching practice of eliciting and using evidence of student learning (NCTM, 2014). During whole group instruction, a teacher might post a question to the class as a pre-assessment or exit ticket. Teachers can also individualise the problems given to students to get a better idea of the needs of each student. When logging into the app, students are able to see the problem assigned and can then videotape their problem-solving process for the teacher to view later (Figure 2). Watching a student's problem-solving process provides the teacher with invaluable information about a student's prior knowledge, possible misconceptions, or even reading and writing skills that may be impeding their demonstration of a mathematics concept. When working on two-digit addition in the classroom, the data collected for the task shown in Figure 2 enables the teacher to better understand what addition strategies her students are using and which approaches might need to be discussed individually or as a class. Again, a wealth of individual student information can be collected with little interruption to the daily class schedule.

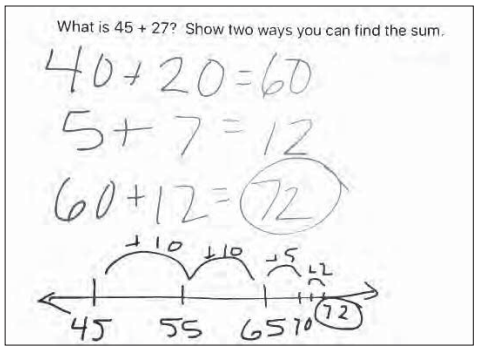


Figure 2. Students can show their thinking about a mathematical problem by recording their work in *Show Me*.

Finally, two teachers who were looking for better ways to assess student learning and share the learning process with both students and parents initiated the use of an online portfolio, *Fresh Grade*. Teachers can create and assign formative assessment tasks through *Fresh Grade* that students can respond to during instructional time using tablets, or at home from their personal computers. Formative assessments can take the form of a formal assessment item(s), posting a written response to a prompt, uploading a picture of student work, or even uploading a video where students show their work and/or talk about mathematics. One teacher chose to

1. 'Mathematics centers' are learning spaces around classrooms, where students work individually or in a group once they have completed their classwork.

upload individual student work (see Figure 3) at the end of class and asked students to log in from home to answer a prompt referencing the graphing task completed in class.

Not only was this an opportunity to reinforce the mathematics lesson, but also the teacher was provided with additional insight into each student's understanding of graphing temperature in a way that could not be accomplished within the classroom.

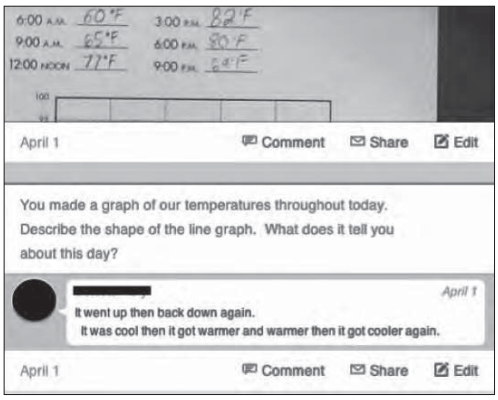


Figure 3. A teacher posts work from a class session and asks students to describe their understanding.

In addition to written responses, this kind of technology also allows students to upload images of their problem solving work as an alternative representation of their understanding. Figure 4 shows a photograph uploaded by a student to the *Fresh Grade* app that records their solution to a word problem using fractions posed by the teacher during class. While the teacher engaged the whole class in a discussion of the solution, having students upload solutions gives the teacher a quick way to reflect on students' individual understandings and address any misconceptions in future instruction. In this case, the teacher was able to see that the student came to the correct conclusion, as well as how the student used drawings to solve the connections being made between fractions, and the creation of equal groups, and how they attached meaning to the sum of two fractions.

Again, teachers can select a format that best fits their instructional plans while gaining insight about how students are thinking about mathematical concepts, their learning trajectories, and what instructional approaches might be needed to address individual needs.

Another great feature about this kind of online portfolio is that students can receive detailed feedback from the teacher that helps them understand their progress towards learning goals in a much more meaningful way than simply receiving a numerical grade.

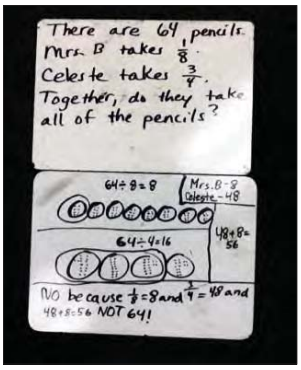


Figure 4. Students can also upload pictures of their problem-solving process.

One teacher posted a photo (see Figure 5) asking students to write a multiplication number story about the baskets of apples shown in the photograph. After students post their responses, this app allows the teacher to provide specific feedback or ask additional questions that can guide student learning. In this way, students are actively engaged in their own learning and are supported in learning to monitor their own understanding and identify next steps based on teacher feedback.

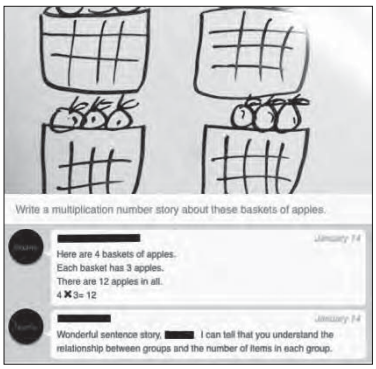


Figure 5. A student responds to a formative assessment task and the teacher is able to provide feedback on each student's work.

How teachers adapted their instruction

How teachers interpret and respond to the information that formative assessments gather is critical to the enhancement of learning. Despite pressure to maintain the pace of the curriculum, teachers felt that adaptations to daily lessons were necessary based on the new data collected from technology. When confronted with evidence that students did not understand a mathematics concept, teachers would incorporate higher-level thinking questions and initiate classroom discussions around a mathematics concept to scaffold student learning. Some teachers would also find time during group work or mathematics centres to meet with students who expressed misconceptions, and elicit further information

about their mathematical thinking process as well as present and discuss alternate ways to understand a challenging concept. In addition, teachers felt better able to identify students who mastered a learning goal and sought ways to provide challenging learning opportunities, which often included the use of technology.

Another frequent way that teachers used the evidence collected from technology-based formative assessment was for flexible grouping. Prior to using this technology, students were often placed in the same groups for support or enrichment. These groups were generally determined by summative assessments, such as the previous unit test or benchmark exams, and did not always align with student understanding and prior knowledge related to the current unit. Teachers were surprised by how frequently students' understanding could change based on the mathematics concept being taught and students were now frequently participating in different groups. As one teacher noted, "I try to stay flexible in any lesson, as sometimes students surprise you about what they need." In response to evidence of student learning collected through technology, teachers created groups for class instruction that would best benefit each student and their current level of understanding. Sometimes, that took the form of a traditional tiered lesson structure where students were grouped by similar needs. However, teachers also felt more confident making groups with varied levels of understanding in order that students might scaffold their peers' learning.

Weighing the pros and cons of technology use

Not all mathematics apps available are efficient and effective in supporting mathematics learning (Larkin, 2013) and teachers must take time to weigh the advantages and disadvantages of using such technology in their mathematics teaching. The teachers featured in this article believed that technology made their instruction more efficient and effective for several reasons. In terms of efficiency, teachers found the use of apps saved time in administering and collecting paper and pencil formative assessments during instructional time. Because the apps were a regular part of their instruction, students were familiar with how to use each app and classroom norms had been established early in the year so that collecting data from students was a quick, streamlined process. Student performance results and teacher feedback could be provided to students and parents faster than handwriting feedback and returning to students, in some cases. The use of technology was also viewed as being an effective approach to engage students and parents in the formative assessment process. Instead of hearing from a select number of students during an informal classroom conversation or when facilitating classroom centers, teachers had access to data that represented all students' mathematical understandings. Compared to paper and pencil assessments, the benefits of the apps teachers utilised include allowing student understanding to be easily tracked over time, enabling the outcomes and feedback to be shared with parents and students online, and capturing individual student's problem-solving processes versus final answers.

As with any technology, teachers must also weigh the benefits against the challenges of implementing technology to determine if its use enhances mathematics teaching and learning. First, learning how to use mathematics apps and establishing norms to make sure technology is used appropriately and quickly takes time. Teachers wanting to use technology for formative assessment should focus on one app they believe would be most beneficial for students, parents, and themselves. While technology was selected because of the time it saved during mathematics instruction, the time to review the data collected and provide student feedback outside of class must be considered when deciding if and when the apps should be used. Again, teachers should consider the value the data collected will add to their instruction, parent communication, and student understanding to determine a realistic approach to implementing the technology.

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