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Screencasts: Formative Assessment for Mathematical Thinking

Melissa Soto[1] · Rebecca Ambrose[2]

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Abstract Increased attention to reasoning and justification in mathematics classrooms requires the use of more authentic assessment methods. Particularly important are tools that allow teachers and students opportunities to engage in formative assessment practices such as gathering data, interpreting understanding, and revising thinking or instruction. Screencast applications on mobile devices enable teachers to collect multiple modes of communications, which students use to generate mathematical explanations. As students' explanations are recorded in the moment and contain verbalizations, written notations, and virtual gestures, teachers are able to gain insights into students' understanding in greater depth than any one mode individually. Additionally, misconceptions and mistakes, which are often lost in written work, are documented and can be identified to specifically target interventions. In this report, a student-generated screencast example will highlight how this technology can be used as a formative assessment tool. Also discussed are potential limitations when using the technology in classrooms and possible solutions.

Keywords Screencasts · Formative assessment · Mathematical explanations · Mobile devices

1 Introduction and Description of the Emerging Technology

Screencasts are not new to education, however, increased accessibility to mobile devices provides teachers and students with new opportunities to engage in them to enhance learning. Educause (2006) defines a screencast as a screen capture of the user's digital

✉ Melissa Soto
melissa.soto@mail.sdsu.edu

[1] School of Teacher Education, San Diego State University, 5500 Campanile Drive, San Diego, CA 92182-1153, USA

[2] School of Education, University of California, Davis, One Shields Avenue, Davis, CA 95616, USA

screen, including the actions, movements, and audio created by the user. Numerous screencasting applications (apps) are available on mobile devices, such as Educreations, Explain Everything, and ShowMe, just to name a few. Although they have varying options, all display a digital white board screen which the user can write or draw on; add pictures, shapes, and text to; and verbalize their thoughts while the entire process is recorded.

Before mobile devices, screencasts were mostly completed on desktop computers with installed software such as Camtasia (https://www.techsmith.com/camtasia.html) or through online sites such as Screencast-o-matic (www.screencast-o-matic.com) and Screenr (which is no longer available). Typically, educators, using this software, created screencasts to demonstrate how to use specific programs or annotate lectures and post them online (Yee and Hargis 2010). A more recent example that readers may be familiar with is Khan Academy, an online site, which houses thousands of screencasts that demonstrate mathematical and scientific procedures. Although an innovative use of the technology, these screencasts duplicated the traditional top-down approach to teaching, in which teachers explain procedures that students are expected to mimic. Another more bottom-up approach to teaching enables students to create their own multi-modal presentations to share their knowledge and understanding with others. With new software available on handheld devices, student created screencasts have become accessible for most classrooms. Since this technology captures thinking in the moment through written work, gestures (with the use of electronic pointer), and verbalizations, teachers have a record of students' thought processes and can use it to gain insights into students' understanding in greater depth than with one-dimensional modes (Jewitt and Kress 2003). In this article, we will discuss the strengths of screencasts as a formative assessment tool as well as some potential limitations when using the technology in classrooms and possible solutions.

2 Relevance for Learning, Instruction, and Assessment

Although screencasts can be developed around any content area, the focus here will be on elementary mathematics, specifically students' problem solving and explanations, which have become increasingly important with the implementation the Common Core State Standards in the U.S. (National Governors Association Center for Best Practices & Council of Chief State School Officers 2010). With these mathematical standards, teachers may need to adjust their perceptions of what it means to learn, teach, and assess mathematics for understanding (National Council of Teachers of Mathematics 2014). This suggests a shift to more formative assessment practices by gathering student data, interpreting it, and modifying instruction accordingly (Hamilton et al. 2009). Formative assessment is more than just evaluating students' performances on a task. It also includes investigating students' thinking/knowledge (why they did what they did), learning potential (what they may be able to master next), and their affect/motivation (how they see themselves as learners) (Ginsburg 2009).

Students' written work tends to be a major data source educators rely on for formative assessment (Little et al. 2003). However, there can be some limitations with written mathematical explanations, as students may not accurately articulate their thoughts or actions. Relying on students' written work alone could lead teachers to make inaccurate judgments about students' mathematical understanding (Crespo 2000).

To augment students' written work, teachers can simply interview students, which can be difficult, as they often do not have time to interview every student individually. The use of technology has become an increasing popular alternative to individual student interviews. One such use of technology involved recording student explanations with digital voice recorders and analyzing them along with students' written work samples (Soto and Ambrose 2014). Another method included videotaping students as they worked together in groups solving mathematics problems (Krebs 2005). These examples illustrate some potential of technology in providing additional data that are often lost when teachers rely solely on students' written work. Some limitations with these technologies may include inconstancies between written work and verbal explanations with digital recorders, which can be difficult to interpret, and the lack of anonymity with videotaping, which can prevent many students from participating.

3 Emerging Technology in Practice

Educators have begun to use screencasts as a tool to record students' work for the purpose of formative assessment. For example, Galligan and Hobohm (2013) analyzed screencasts generated by pre-service teachers to examine their depth of mathematical understanding and explanations. Richards (2012) found that when middle school students generated screencasts as a group, they were motivated to work together because it gave them control of their learning and allowed them to document their understanding in ways that made sense to them. In both of the aforementioned studies, students generated their screencasts after they solved tasks. Their screencasts were final products and may not have contained the rough draft thinking or initial thoughts of the students as they began the tasks. Other researchers have investigated student-generated screencasts from elementary level to high school, while they solved problems and constructed explanations (McDougall and Karadag 2008; Soto 2015). One study revealed that elementary students who generated screencasts as they solved multiplication and division problems framed their explanations to ensure that the potential audience understood their reasoning (Soto 2015). These studies have established the benefits to students when they generate screencasts.

We have also found screencasts to be a powerful assessment tool in our own work with students. Here, in this example Beatrice,[1] the youngest participant from a previous study (Soto 2015), solved a partitive division problem, 32 balloons divided into 4 groups. Her final screenshot, Fig. 1, displays her solution, however, her final answer was missing and how she went about solving the problem was unclear from this static display.

The temporal component of her screencast indicated that Beatrice systematically divided her workspace into quadrants (first row in Table 1) and distributed the tallies. The problem was presented to Beatrice in Spanish, her first language, but she spoke in English while she solved the problem. The voice recording added further information about how she counted.

In Beatrice's work, rather than distributing the tallies by ones, she first allocated four tallies to each quadrant. Once she distributed four groups of four, she counted them to determine how many she represented. She counted the first four tallies by one and then skip counted saying, "eight." She continued to count on from 8 by ones, but she skipped to the number 11 as she continued counting by ones. When she recounted to ensure she had the total amount of 32, she was short 2. She momentarily disregarded the criteria that every group had to have the same number of balloons and added the extra two to the last group. She failed to satisfy the requirement that each group had to have the same number of

[1] Student name is a pseudonym.

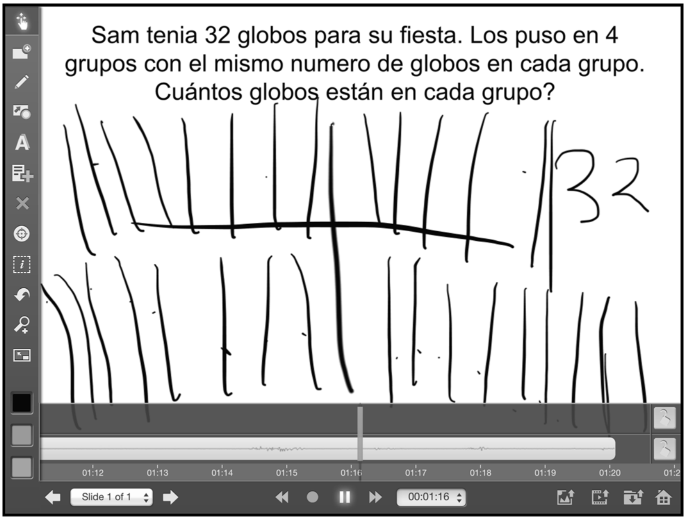


Fig. 1 Beatrice's partitive division final screenshot

objects. Although her final solution was incorrect, her solution strategy demonstrated that she understood the context of the problem and knew to distribute the balloons among the children. If the audio recording was not connected to the written work, it could have been incorrectly concluded that Beatrice misunderstood the problem from the start.

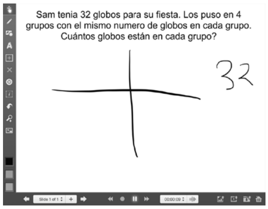
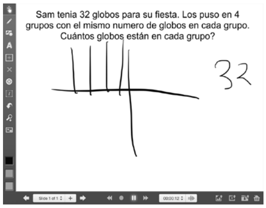
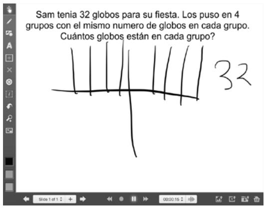
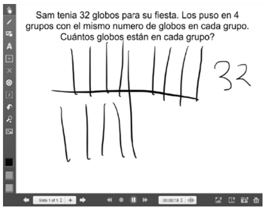
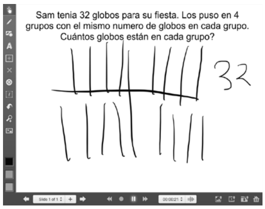
Beatrice was very excited about using the app and was eager to get started. Before generating her screencasts, she indicated that to her, being "good at mathematics" meant solving problems quickly. This may provide some insight into Beatrice's motivation (Ginsburg 2009) for adding the two tallies to the bottom right quadrant of her picture rather than recounting them. She may have wanted to finish quickly to show how "good" she was at mathematics. With the temporal component of the screencasts, the audience can view how long it took her to solve the problem and possibly provide targeted suggestions that may help her slow down and revise her work. Beatrice's example shows that screencasts can provide teachers with more nuanced data than static written work so they can better tailor their instruction to meet their students' needs.

4 Significant Challenges and Conclusions

Because screencasts capture multiple modes of communication, teachers have more data to analyze rather than a static, written artifact alone, which could help them make more informed instructional decisions. Screencasts can also enable a bottom-up approach to education where students generate knowledge rather than receive it, particularly if they are given the opportunity to revise their presentations.

Some challenges to implementing screencasts in classrooms include data overload, access, inadequate professional development or skepticism from teachers, and limitations with the technology. With the amount and complexity of the data generated by students, it could be difficult for teachers to analyze and make decisions based on the data in the moment. It could also be time consuming to view the screencasts to select clips to share as

Table 1 Beatrice's partitive division screencast transcript

Time	What was said	Screenshot
0:04–0:09	So 4 groups, he wants 32 balloons in total	
0:10–0:12	So I'm gonna do, one, two, three, four (spoken as tallies are written)	
0:13–0:15	One, two, three, four	
0:15–0:18	One, two, three, four	
0:18–0:31	One two, three, four (*Went back and counted all the tallies.*) So, now I'm gonna make the total 1, 2, 3, 4, **8, 11 (sic),** 12, 13, 14, 15, 16, 17, 18	
0:31–1:20	(*Began adding additional tallies by ones to each quadrant.*) 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32 (*Went back and counted all the tallies, made dots next to some tallies.*) So, let's see, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30 (*Paused, added two tallies to the bottom right quadrant*) 31, 32. I'm all done	

examples in the classroom or to evaluate students' understanding. As Siemens and Long (2011) indicate, "Quantity changes the methods and approaches that we use to interact with and make sense of data" (p. 32). Teachers will need to decide how often they ask students to generate screencasts and whether all the students will generate them during the day. Alternatively they could only select a few children to generate screencasts, or perhaps students could pair up and generate one screencast. How teachers navigate between the devices and numbers of students is important to consider and more research on the logistics of implementing in a classroom setting are warranted. Although screencasts provide a multitude of data sources, quickly and succinctly analyzing the data will need to be addressed, as currently learning analytic programs are not available.

Another challenge to implementing screencasts is the availability of mobile devices in schools. Some classrooms may have only limited quantities to no mobile devices. Some classrooms may have a "bring your own device" policy in which case teachers will need to ensure that each device has access to a screencasting app and decide if all students will use one particular app or if any app will suffice. If schools and classrooms do have limited quantities of mobile devices, one possibility would be for students to share and work in groups as they generate their screencasts and collaboratively construct explanations (Culén and Gasparini 2011).

Inadequate professional development of the new technology may limit teachers' success in using screencasts for formative assessment (Bingimlas 2009). Teachers also may be skeptical of the technical infrastructure available for them in order to successfully implement the technology (Ifenthaler and Schweinbenz 2013). Thus professional development must go beyond mere learning about technology to learning how to use technology tools for the purposes of supporting instruction (Lawless and Pellegrino 2007).

Lastly, screencasts are tools to help teachers peer into their students' minds. At times, the technology may not capture all of the intricacies of students' explanations such as when students count on their fingers or use manipulatives. Students may need practice documenting their thinking, be encouraged to speak and share their thoughts as they solve problems, and learn to be patient with the technology, especially if the apps unexpectedly crash or their work does not save. Even with these limitations, the potential screencasts have particularly for formative assessment in mathematics is noteworthy and deserves continued research.

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