STUDENTS’ USE OF SCREENCASTING TECHNOLOGY TO EXPLAIN THEIR MATHEMATICAL THINKING

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ABSTRACT

Using meaningful technology can enhance teaching and learning. Some of the enhancement today is due to more accessibility by integrating mobile tablets. Students can efficiently generate verbal and visual explanations using screencasting applications (apps) on tablets, which open a window into their formative thought process. In this study, I sought to analyze the benefits of using screencasting when students generated explanations during mathematical problem solving. I interviewed 9 students between the ages of 7 and 10 as they solved problems on a tablet using a screencast app, Explain Everything® (EE). I analyzed the 45 student-generated screencasts, guided by the SAMR Model to investigate how students used the tool in a transformative manner. Because of the variety of tool options built into the EE app, students were able to role-play as a teacher and generate more robust explanations. I conclude that screencasting has the possibility to transform a learning environment by allowing students to create multimedia presentations and reflect and remediate in real time.

Keywords: Screencast, mobile learning, reflection, SAMR Model.

INTRODUCTION

With the increased accessibility of mobile technology, researchers and educators have found ways to capture students’ understanding in more meaningful ways. Screencasts are a promising way to take advantage of mobile technology in teaching and learning. Educause (2006) defined a screencast as “a screen capture of the actions on a user’s computer screen, typically with accompanying audio.” Although screencasting software was originally designed for desktop computers, it has become more readily available through tablets as applications (apps).

Teachers or professors have generated screencasts for many years as they recorded lectures and demonstrations for their students and posted these on their course management systems (Educause, 2006; Yee & Hargis, 2006). The advent of more affordable and accessible screencasting apps have allowed for a shift in teaching practices and have placed students in the role of creator. These apps can be also be used to assess students understanding as they generate
screencasts to communicate their understanding and processing, reflect by viewing their screencasts, and make adjustments when needed.

Since this technology captures thinking in the moment as well as many nuances of students’ explanations, e.g. the written work (symbolic and graphic), gestures (with the use of electronic laser pointer), and verbalizations, teachers can examine students’ final answers and gain insights into how students’ processing unfolded.

The screencasting app that was selected for this study was Explain Everything® because of the variety of tools and functions it provided. I hypothesized that these options could help students create learning artifacts that have not previously been seen in classrooms. To create these artifacts, students need meaningful tasks and the mobile learning tools need to be purposefully integrated. Puentedura’s SAMR model; Substitution, Augmentation, Modification, and Redefinition, provides a framework for implementing technology in ways that transform the learning environment (Hargis, Cavanaugh, Kamali, & Soto, 2014). I believe that when students generate screencasts, they can communicate more effectively and monitor their mathematical understanding (Chi, Siler, & Jeong, 2004; Martin, 2012).

In this study I will share student screencasts in which seemingly ordinary tools were used in specific ways and students generated artifacts they could not create without the technology and enhanced their explanations. I will particularly focus on the eraser, pen color, shapes and duplicate option, laser pointer, and the playback function.

LITERATURE REVIEW

The use of mobile learning tools in classrooms has increased drastically. There are many papers that cite the use of these technologies in higher education (Culén & Gasparini, 2011; Hargis & Soto, 2013; Hargis, Cavanaugh, Kamali, & Soto, 2013a), while others have reported the increased used in K-12 education (Magan, 2013; Smieja, 2012; Whitlock, 2013). One such example included third through sixth-grade elementary students in Encinitas School District, just outside of San Diego, California, which received iPads in 2013 (Whitlock, 2013). Many of these studies have focused on the feasibility of usage by students (Culén & Gasparini, 2011), student engagement (Whitlock, 2013; Hargis, Cavanaugh, Kamali, & Soto, 2014), teacher implementation practices (Benton, 2012), and the impact on student learning (Smieja, 2012).

Although some reports highlight the impact of technology on student learning, it appeared that the primary use was drill practice. In a Minnesota school district, teachers and administrators decided to pilot iPads in selected classrooms as opposed to full district wide implementation (Magan, 2013). After six months of usage, teachers “found iPads were an effective way to help struggling students learn. Several tablet applications provided students with both the repetition needed to master skills and novelty to keep them interested” (Magan, 2013, para. 5).

Although encouraging that teachers and students were excited about the technology, the initial use was procedural and “supplemented traditional lessons in handwriting, letter recognition, and math drills” (Paul, 2013).
Critics of educational technology complain that with the introduction of virtual games, students will become bored with traditional tasks (Paul, 2013) or that technology will diminish teachers’ roles.

Technology can offer advantages, however, Puenteundra (2013) stresses, 1) teachers and educators need to understand the affordances of the technology before implementing, 2) tasks should be meaningful, and 3) the technology should be used to enhance student learning outcomes. Johnston and Stoll (2011) believe that technology “is a tool, like any other, and in the classroom it must always be thought of as being in the service of pedagogy” (para. 9).

Implementation of meaningful technology can affect student-learning outcomes. Some of the reports above discussed that tablets and particular apps helped students learn mathematics by drill practice and repetition. It is our hypothesis that student work generated using mobile learning tools could positively affect students’ learning as well as teachers and peers’ learning. For example, screencasts could be used as a met cognitive tool for students to reflect on their thinking. They could also be used as a communicative tool for students to report their understanding to others. For teachers, the tool could provide insights into the ways students solved problems, including their false starts and misconceptions (Soto & Ambrose, 2015). In these ways, student generated screencasts serve as boundary objects. Star and Griesemer (1989) defined boundary objects as, “objects which are both plastic enough to adapt to local needs and the constraints of several parties employing them, yet robust enough to maintain a common identity across sites” (p. 393). So screencasts serve different purposes for different individuals using them in a variety of settings.

SAMR Model

The SAMR model developed by Puenteundra (2013) has helped educators and researchers consider how the use of technology in the classroom affects student outcomes. His model includes four levels, which include the Substitution, Augmentation, Modification, and Redefinition (SAMR) levels. Before identifying which level of technology integration was achieved, educators must first identify the affordances of the technology.

The next step in technology integration involves identifying which type of educational technology is most effective in the classroom. Puenteundra (2013) explained that the use of technology has been researched and shown to allow students to be more exploratory, creative, and responsible when they actively link new knowledge with other data. Once specific discussions on effective instructional technology have occurred, then the SAMR model becomes an integral part of successful implementation.

The initial two levels of the model, Substitution and Augmentation, are the first steps to implementing technology but do not significantly alter the learning outcomes. The top two levels, Modification and Redefinition are levels in which technology significantly enhances the learning experience and transforms the learning outcomes.
Although there is a hierarchy among these levels, certain tasks and technologies can be classified in any one of these levels depending on how they are presented and used in the classroom.

Also, it is not necessarily “bad” to use a technology for Substitution purposes; it could be a first step in using the technology and may be sufficient for a particular task. It is critical to consider the learning outcomes before implementing technology and let the outcomes guide the type technology to enhance the learning.

Before investigating how teachers use new technology in their classroom, it seems appropriate to first investigate how student engage with the technology. I believe there are multiple ways which screencasts could be transformational. First, because most screencast apps provide students with tools, students have the ability to make a variety of representations and edit their artifacts.

Second, as students’ record, they can use alternate modes of communication to express their solution and take on different personas (Soto, 2015). This may encourage students to increase their affect and motivation (Ginsburg, 2009) when it comes to engaging in the mathematics because they can use their strengths, verbalizations, notations, or gestures to communicate their understanding and display their personality.

Finally, as students record and then view their screencasts, they have a permanent record of their problem solving process. This provides students with multiple opportunities to reflect, evaluate the reasonableness of their solution, revise, and develop a deeper understanding (Chi, De Leeuw, Chiu, & LaVancher, 1994).

In this investigation, I sought to examine the following research question: How do students engage in the application’s options when generating mathematical explanations and screencasts

METHOD

In this study, 9 students between the ages of 7 and 10 were recruited through convenience sampling to participate in clinical interviews (Ginsburg, 1997). Because this investigation was descriptive and examined how students engaged with the technology, I do not intend to generalize to the larger population. Student participants were interviewed one-on-one at least once and were asked to solve three to five multiplication and division story problems on an Apple iPad with the Explain Everything® app. Prior to the interviews, students participated in an app training session in which they learned about and familiarize themselves with the different options and functions of the app and had the opportunity to practice generating screencasts.

To generate their screencasts, the author read the story problems aloud to the students and asked if they had any questions about the problem. Students then pressed the record button on the bottom of the screen and began recording their screencasts. They read the problem aloud again and used any of the tools to as they solved the problem and explain their thinking. Once they finished, they pressed the record button again to stop the recording, we then viewed their screencasts together, and the author finally asked them to reflect on their work and what they would change if they recorded the screencast again.
For specific problems, particularly the equal sharing story problems, students were then asked to record a second, polished screencast. After they recorded and viewed these screencasts, they were asked to compare their first and second screencasts.

Data analysis began with the transcription of each of the 45 screencasts generated by all the students and the audio recordings of the entire interviews with the students. Interviews were transcribed in full to retain the students’ words for future reference (Seidman, 2006). Once all the data were transcribed, they were read through multiple times, I wrote notes, observations, and interpretations, which turned into codes.

These codes were guided by previous literature, specifically what types of explanations students generated (Ericsson & Simon, 1998; Kazemi & Stipek, 2001), details of their solution strategies (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989), the congruency of their notations and verbalizations (Schleppegrell, 2010), the tools they used, and the changes in their solution strategies. These codes were then compiled and a rubric created.

RESULTS AND DISCUSSION

Tool Options

Of the 45 screencasts generated by the students, 21 contained explanations that used three or more tools from the app. Students also used these tools in a variety of ways, for different purposes. If students wished to use only the drawing pen, what I considered to be a direct Substitution, they were able to do so. However, the app also allowed for Redefinition of tasks in which students could create learning artifacts that were more elaborate, using additional options. Although some of the tools and functions could be considered direct Substitution, for example the eraser and change of pen color, the way they were used could be considered higher-level technology integration. In the following sections, I will discuss how students used the eraser, pen color, shapes, and laser pointer to generate explanations that previously have not been possible.

Eraser

Students used the drawing pen with black ink most often, perhaps because it is the default color. After the drawing pen, one of the most frequently used tools was the eraser. A benefit of combining students’ verbalizations and written work was that a permanent account was created of what students said, wrote, and what they erased.

![Figure 1. Student JR’s Partitive Division Balloons Initial Solution Strategy](image)

Sam blew up 36 balloons for his party. He put them into 4 groups with the same number of balloons in each group. How many balloons are in each group?
I have observed teachers attempt to decipher students’ written work on paper, particularly their erasures, to determine exactly what students did to solve the problem. Often times with student written work on paper, it is impossible to determine what was erased or even why the student erased it. With screencasts, even though students erase their work on the screen, teachers could still view and have documentation of students’ thought processes, which could aid in monitoring student’s mathematical understanding (Chi et al., 2004; Martin, 2012). In this example, student JR began solving a problem correctly and then erased all his work when he did not make equal size groups.

He attempted to solve the partitive division problem in which 36 balloons were placed in 4 bunches. When he began, he did so in a way that was consistent with the action in the problem by partitioning the balloons into groups (Figure 1). Rather than distributing the balloons by ones, he decomposed 36 into 3 groups of 10 and 1 group of 6. He next tried to meet all the criteria of the problem that there had to be the same number of balloons in each group. He crossed out the first circle with a 10 and wrote a 5 at the bottom of the screen. He then did the same to the second circle with a 10 (Figure 2).

![Figure 2. Student JR’s Partitive Division Balloons Intermediate Solution Strategy](image)

At first glance it appeared that he wrote 55 on the bottom of the screen, but the screencast recorded how he wrote the first 5 after crossing out the first group of 10 and wrote the second 5 after he crossed out the second group of 10. He then erased everything on the screen and went in another direction.

Although he did not say much as he solved this problem, the recording of the written work provided some insight into what he was thinking. Even though student JR erased all his work, his correct start to solving the problem was documented, and it provided evidence of his ability to decompose numbers and his base 10 understanding.

Since screencast have a temporal component, the audience has the ability to see what was erased and when, which could provide insight into students’ understandings or misconceptions.
Pen Color

Five students took advantage of changing the color of the drawing pen while generating their screencasts. Three of the five students often did this to represent or highlight different aspects of their explanations. They did not randomly change colors, but were purposeful and strategic when they changed colors in the middle of their recordings.

Two students, student JR and student S, before recording their screencasts, selected their color options and had them ready on the side of the screen so they could quickly change from one color to the next. When student JR solved the equal sharing play dough problem (Figure 3), he used blue tally marks to represent the four children.

As he made the tally marks he said, "There’s (sic) 4 kids that are playing with 10 pieces of play dough...." He then went on to distribute the "pieces of play dough" which he represented with red tallies.

![Figure 3. Example of Student JR's Use of the Pen Colors](image)

When student JS solved the equal sharing play dough problem, she changed colors to represent the different parts of her division algorithm (Figure 4).

After she solved the problem with the algorithm, she returned to describe each part of the algorithm using the laser pointer.

She first circled the "R2," then the "2," and said, "This is my remainder. This is my answer." She then circled the four and said, "this is my...uh, uh." When I listened to her screencast afterwards she said, "I forgot the name of it, the quotient is the... I should have said the quotient."

She mistakenly called the four the quotient rather than the divisor. For student JS, she wanted to ensure that she clearly identified each part of the problem. It appeared that the changing of the colors was one way she attempted to help the audience follow her explanation.

However, just as teachers use multiple representations to explain, student JS used the different colors and laser pointer to make sure that her explanation was clear.
The eraser function and changing the pen color, although they could be done without the technology, were just the beginning of what students could use to more fully express what they knew and help the audience follow along. There were other options available, including the shapes, duplicate, and laser pointer, and that students used to transform the task and entered into the SAMR levels of Augmentation, Modification, and Redefinition (Puentedura, 2013).

**Shapes and Duplicate**

One option available was the use of shapes, in which students could select from a limited number of pre-made figures. The most common were the circle and rectangle, but others included a star, line segment, and arrow shape. Another feature that was used frequently with the shape tool was the duplicate option. Rather than attempting to make multiple shapes the same size, students could use the duplicate option to copy and paste the same object on the screen. Of the 9 student participants, 4 used the shape and duplicate tool at one point during their interviews. In total, 9 of the 45 screencasts (1/5 of the total) contained these pre-made shapes.

When students used these tools in 8 of the 9 screencasts, the shapes were used to represent the groups in the story problem and/or the objects in each group (the balloons or children). Two of the four students that used the shapes and duplicate tools solved the problem using the traditional division algorithm but used the shapes to clarify their answers. For example, student M solved the portative division balloons problem using the division algorithm. She then made one circle and duplicated it to make a total of four circles, which represented the four groups of balloons (Figure 5).

She then went on and said, “so then in the 4 groups there are 23 in each group. In each group, so Sam and the 4 groups has [sic] 23 and that is the answer” (student M Balloons 3 Screencast Transcript, May 31, 2013) as she used the laser pointer and circled each of the red circles she made. So although she did not use the shapes to model the problem, she used them to help reinforce the context of the problem and the meaning of the 23, the quotient she calculated when she used the algorithm.
Students did something very similar when she solved this problem except she distributed all 92 balloons by ones to the 4 groups.

Sam blew up 92 balloons for his party. He put them in 4 groups with the same number of balloons in each group. How many balloons are in each group?

Figure 5.
Student M’s Use of the Shapes Option

During pilot testing, 3 of the 4 participants described their screencasts as “messy.” I hypothesized that students would use the tools, particularly the shapes and duplicate tool to help organize their work.

This was not entirely the case, only one student, student M, after she solved the equal sharing problem for the first time commented that her work was “messy” and asked if she could use the shapes to make it more organized.

Table 1 contains a before and after of how she used these tools to make her notations clearer. As can be seen in the “Before” column, student M’s work was difficult to interpret.

She used tally marks to represent the cans of play dough; however she does not draw them in a way that helps to distinguish between whole cans and half cans.

Yet in the “After” column, she used the pre-made rectangle to represent a can and duplicated it for the rest of the cans of play dough. This clearly indicated that each mark represented the same amount, i.e. a whole can.

To show that some of the cans would be cut in half, student M used the pointer to “cut” through some of the cans and indicated that those parts would then be distributed to the other children to share.
Table 1.
Student M’s Before and After of the Equal Sharing Play Dough Problem

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 children are sharing 10 cans of play dough so that each child gets</td>
<td>4 children will share 10 can of play dough so that each child gets</td>
</tr>
<tr>
<td>the same amount. How much play</td>
<td>each child get?</td>
</tr>
<tr>
<td>dough should each child get?</td>
<td></td>
</tr>
</tbody>
</table>

Although only 9 of the 45 screencasts contained the pre-made shapes, and students did not use them as often as predicted. Perhaps one reason may have been that not all of the problems students solved involved distributing known numbers of objects to groups. A different set of problems might have yielded more extensive use of this tool such as measurement division problems where the number in each group is known. Also, some of the problems involved large numbers that would have been tedious for students to make individual shapes to represent those numbers.

Laser Pointer
Another tool that students used was the laser pointer. In a way, this tool added gestures and motion to the students’ screencasts. When explaining a solution to someone on person, students can point to different notations on their paper or refer to the problem.

However, with the mobile learning tool, when students point to something on the screen, the audience watching the screencast cannot see what the student referred to.

Students used the laser pointer to highlight anything they wanted to reference on the screen without leaving a mark or adding additional stray lines. Sometimes, when students counted dots or objects on the screen, they used the laser pointer, which highlighted the objects that were being counted.

Students also used this tool to explain what would happen if they did particular actions.

For example, when student S solved the equal sharing play dough problem for the second time, she equally distributed eight dots into four groups with two dots in each group. She then discussed how it would be unfair if she gave the last two dots to the first two groups, "if I put 1, 2, that would be 9, 10. Right? So, it wouldn’t be fair, and these two circles wouldn’t have third ones" (student S Play Dough 2 Screencast Transcript, June 1, 2013).
As she said this, she used the laser pointer to pretend she placed those final two dots in the first two circles. She then used the laser to circle the final two circles to show how they would only have the two dots and not a third one.

She did not use the pen to mark up the first two circles with extra dots because she knew the groups needed to be equal and she would just end up erasing them. She used the laser pointer to show what it would look like if they did have the dots. Other students used the laser pointer in similar ways, for example student M and student JR used the laser pointer to pretend they were cutting through objects.

The use of this option not only transformed students’ work to something more than Substitution, but students also created mathematical explanations that went beyond how and why they solved the problems. I believe that when students used this option, they had the audience in mind and tried to make their explanations clear, which added to the teaching persona aspect of their explanations. This included making sure what they referenced was easily identifiable to the audience. The use of the laser pointer also expressed additional thoughts that were not communicated through students’ words or notations. Goldin-Meadow (2004) describes such a case when gestures and speech do not convey the same information as “gesture-speech mismatches.” She described these cases as times when students have not integrated the information from both modalities but could benefit from instruction.

Since screencasts capture only data that were written or spoken when the app was recording, gestures, which are nonverbal forms of communication, could be lost, particularly if students have not integrated the information from the gestures into their speech or notations.

These extra data could easily have been missed or omitted from the students’ mathematical explanations had only paper and pencil been used. However, when students generate screencasts that pair the speech, writing, and gestures, they can generate more detailed explanations, and their screencasts could give teachers more access into their students’ thought processes. I have discussed ways in which students used the different tool options as they generated their screencasts, and how they used them to clearly express their explanations. In the next section, I discuss an option that transformed the conversations that occurred after students solved the problems and the nature of the interview process, the playback function.

Playback Function
Affordances were actualized when students used the playback function. These include the potential to help increase students’ productive dispositions and students reflecting on their mathematical thinking, and how the use of this function promoted discussions and reflection.

Productive Dispositions
Self-efficacy is “the conviction that one can successfully execute the behavior required to produce the outcome” (Bandura, 1977, p. 193). So having a high sense of self-efficacy can help people persist when faced with challenges and help them believe they can accomplish a goal that they otherwise may not have attempted.
For mathematics proficiency, the National Research Council (NRC, 2001) identified productive disposition as an essential component for students to “see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one’s own efficacy” (NRC, 2001, p.116). Not only is this sense of productive disposition important for students to possess, it is also important for teachers to assess and monitor their students’ affect (Ginsburg, 2009).

During the app training, I explained how the tools worked and provided students an opportunity to practice record a screencast and then play it back. The students were very interested in this playback function and commented on how they thought it was “cool.” Not only did many students enjoy listening to their screencasts in this study, but also I hypothesize that engaging in the playbacks have the potential to help build students’ productive disposition.

One particular student, student ML2, really enjoyed playing back his screencasts. When he watched his practice screencast, the moment he heard his voice, a smile came across his face.

This did not just happen once, but every time he replayed his screencasts he would smile and using his finger like a pen, would write in the air and mimic everything he wrote on the screen (Field Notes, July 29, 2013).

At the end of his interview he was asked,

- I: Whenever you listen to them, you get really excited and you look at me and you smile, what are you thinking in your head when you’re watching these?
  - ML2: I’m thinking that I did really good because I’m happy that I’m listening to my own self doing something because, because I’m really happy that I’m listening to myself because I know that I did really good at it.
- I: So is it that it’s exciting to hear yourself when you’re doing something good or just exciting to listen to yourself no matter what?
  - ML2: I’m excited to listen to myself when I, when I think I did really good. (ML2 Audio Transcript, July 29, 2013)

Although student ML2 struggled, he was still excited about using the technology, solving the problems, and making his screencasts neat and clear. It may have been that this was a novel item or situation and that may have made him eager to participate. However, he felt like he had performed well and was proud of himself.

Even though a productive disposition or high self-efficacy alone will not make someone proficient, if students have positive attitudes about themselves as learners, they may be more willing to persist and put forth more effort when they struggle (Bandura, 1977).

For teachers, they may be more successful in helping struggling students with productive dispositions than those who feel defeated and lack positive affect. Students were excited to share their screencasts with me and rather than wait to be asked if they wanted to watch their screencasts, they initiated the viewing.
For example, in the interview with student S, after she finished recording her first screencast solving the portable division balloons problem, she asked, "Are we going to watch it?" (Student S Audio Transcript, June 1, 2013).

After this, there were no other options than to replay her screencasts, she would quickly ask after finishing her recording, "Ok, so are you ready to listen?" or "Let's watch it" (student S Audio Recording, June 1, 2013).

During the first round of interviews in Florida, students were unable to watch their screencasts. Student JG after solving the multiplication sticker problem said, "It would be cool if I could see that" (student JG Audio Transcripts, June 27, 2013). I believe that had the app been functioning properly, students in Florida would have taken the same kind of initiative as student S did in California with the playback option.

Reflecting on Thinking
Another affordance of the playback function was that it allowed for the opportunity to reflect on what was just completed. Students could use this function to review their screencasts and either expand on their explanation or revise their thinking. I hypothesized that the process of playing back their screencasts could serve as a cue for the students to prompt self-evaluation, much like the tutees for the tutors in Roscoe and Chi's (2004) article. Although they concluded that their face-to-face tutoring session resulted in more sense making by the tutors than in the session where the tutors videotaped themselves explaining, it was unclear whether the tutors in the videotaped session had the opportunity to view their recordings.

In this investigation, the students had the option to view their screencasts and out of the 30 occasions when students viewed their screencasts immediately after recording, only after 2 did students spontaneously verbalize that they noticed a flaw in their thinking and 1 commented on how she could have added to her explanation.

Other students may have realized a flaw in their thinking or that they could have elaborated on their explanations, however, only on these three occasions did the students verbalize their realizations. One of those occasions with student M are detailed next.

When student M solved the portable division balloon problem, she described what she did to solve the problem as she was doing so. She picked the numbers from the problem (92 balloons distributed into 4 bunches) and multiplied them to get a total of 328.

After she watched the screencast she giggled and I asked her why she laughed. She then had what I perceived as an "ah-ha" moment.

Student M: Oh! Ok.
I: What?
M: No, I think I got it wrong.
I: Why is that?
M: Because it says how many balloons are in each bunch and they [sic] can't be that much balloons in each bunch.
I: And what made you think that? What made you change your mind?
M: Well because, there’s 4 and there’s 92 and they want to know how many are in each little circle but there’d be too many to go in each circle. (student M Audio Transcripts, June 1, 2013)

She was facile with the multiplication operation but realized that it was the wrong operation to use because the product she calculated was too large for the context of the problem.

It was not clear if it was watching the screencast that made her realize her error, i.e. hearing herself she might have realized that she made a mistake, or if she reflected more on the problem because of the questions asked. However here, I just asked what she was laughing at and she made this revelation.

Although she recognized that the answer from the multiplication would result in too many balloons in each group for the context of the problem, she still struggled to solve the problem. It took her two more attempts to solve it.

In the second screencast she generated for this problem, she subtracted the 2 numbers and said there would be 88 balloons in each group. Unlike before when she watched the screencast and realized multiplication did not make sense, she did not realize that the subtraction produced a nonviable solution. I asked her if each group had 88 balloons, then how many balloons would Sam (the person in the story problem) have altogether, and she quickly said, more than 92! She then went on to say, “Because I did multiplication and it gave me a lot and then maybe subtraction would take some away, but it still had more, but maybe subtraction would still give it more, but it could be division” (student M Audio Transcript, June 1, 2013). So in this quote, she revealed that she had to have a smaller number in each of the circles. She already tried multiplication and that did not work so a way to get a smaller number, for her, meant to subtract.

It appeared that to her, getting a smaller number always meant subtraction and that was what she did, she did not think twice about it not producing the correct solution to the problem. It was not until I asked her how many balloons she would have altogether that she realized that it would still be too much. She said she could try division, and after she finished solving the problem using the division algorithm she said, “That makes more sense. Because it’s not that much and maybe if you add those up they’ll give you 92 so then I will be right” (student M Audio Transcript, June 1, 2013).

Although she caught her first mistake, student M did not realize that when she subtracted, she still would have too many balloons in each group. This was very similar to student K, the second student who verbalized that she made a mistake in her screencast.

She was able to recognize that she was confused; however, she was not sure where to go next, just as with this example with student M. It was through my interactions with the students, asking them questions, and encouraging them to reflect on what they did, which enabled students to revise their solution strategies.

These two occasions, with student M and student K, illustrated how allowing students to view their screencasts could be beneficial in helping students reflect on their thinking.
Student S, after watching her screencast where she solved the practice version of the equal sharing play dough problem, realized she could have elaborated more on her explanation to make her thinking more explicit (Soto & Hargis, 2014).

Although students may have actualized this affordance of viewing their screencasts and revising their thinking, opportunities existed for growth and improvement in the area of reflection and self-evaluation.

It would seem then, since the majority of students did not verbalize that they noticed a mistake in their explanations, that simply asking students to generate these screencasts and review by themselves may not be the most effective way to promote self-evaluation at least in the beginning of generating screencasts. This supports the idea that interaction between students and teachers or students and other students is still important.

These findings were in line with what Roscoe and Chi (2004) found in their tutoring study. Those tutors in the condition in which they recorded their lessons were less likely to self-evaluate their explanations because they did not have tutees to question their explanations or provide cues of the discrepancies. Even though the students in my study had the opportunities to review their screencasts, the majority of the time, they did not verbalize their self-evaluating thoughts.

Promoting Discussions
Since students only revised their thinking after viewing their screencasts on three occasions, it was evident that student/teacher interactions were still vital. One feature of the playback was that, not only could teachers watch the screencasts in their entirety, but they could also rewind it to particular instances and playback from there. Using this feature in this way could be an affordance for teachers to help guide discussions.

Previously, student JR began solving the partitive division balloons problem. After he erased his initial notations from the screen he tried multiple strategies to solve the problem, however he struggled.

After he worked on the problem for about 10 minutes I stopped him to ask how things were going. He replied, "It's not going too good. I keep thinking about ways like, ways to make, ways to make 36 in 4 groups and it's getting confusing” (student JR Audio Transcript, June 25, 2013).

Because I watched him solve the problem, I remembered how he initially began solving the problem by decomposing the 36 into 3 groups of 10 and 1 group of 6. This strategy had promise, yet he abandoned it and I wanted to return to it to see what he was thinking and why he decided to go in another direction. I asked him if he could provide more details about the strategy he tried when he first began solving the problem.

He thought for a moment and then said, "I started counting by twos to 36..., so I'll write eight, two 18 times and then I start adding, adding the 2s together to make like 4s and then I added the 4s and then there was just like, there was only like, 3 but there was like 1 left.” (JR Audio Transcript, June 25, 2013)
He described the second strategy he tried after he erased his screen. In this second strategy, student JR wrote the multiples of 2 on the screen up to 36.

He then went back, wrote the number two on top of each multiple, and counted how many twos he wrote (Figure 6).

On a second screencast (his first one stopped recording unexpectedly), he began by writing 18 twos and added the 2s together to make 4s, and continued combining them until he had two 16s and a 4 left to combine (Figure 7).

Sam blew up 36 balloons for his party. He put them into 4 groups with the same number of balloons in each group.

How many balloons are in each group?

Figure 6.
Student JR’s Attempt to Determine the Number of Twos in 36

Figure 7.
Student JR’s Solution Strategy to Make Four Equal Groups

He was correct in that this was how he started solving the problem the second time, however, I was interested in his very first strategy. Rather than simply asking, “how did you start solving the problem,” I could have been more specific and directly asked him what he was thinking when he decomposed the 36 or I could have used the rewind function.

The bottom of the app’s screen contains buttons that record, pause, rewind, and fast-forward the screencasts, as well as a timer that displays the length of the recording. With many of the other screencast apps commercially available, you can only play and pause the playback. The rewind and fast forward buttons on the bottom of those app’s screens will only take the viewer to the beginning or the end of the screencast.

Meaning, if teachers watching a screencast miss something, they have to start watching from the very beginning to see what they missed.
However, the developers of the Explain Everything® app added a function where the viewer can rewind to the parts that were missed or that they would like to view again. By pressing the timer, a hidden toolbar appears and the viewer can rewind to the desired spot of the screencast.

By scrolling back and forth, one can see the sound recording, which tools were used and how long the student used that tool, and the notations on the screen disappear or appear so one can see how the screencast unfolded to find the exact location to view. This function was not only useful as researchers when transcribing, but it was also helpful when interviewing the students. I was able to return to specific moments in time and replay them, almost like having students relive the moment to see if I could get them to remember and verbalize what was going on in their minds and describe why they did something.

Because of the immediacy of the playback, the ideas may have still been fresh in the students’ minds so they were able to provide additional information that might have been lost. It could also spark new discussions of other topics that could come out from reviewing specific sections in isolation. Unfortunately, with student JR, the app’s update did not allow the rewind option to function properly and so I was unable to go back to the notations he erased. However, I did rewind particular screencasts with other students when I was unsure what they did and wanted more information.

An example of when I actualized this affordance was with student ML1. When she solved the equal sharing candy bar problem, she solved the problem by counting by threes. Table 2 shows her initial solution of this problem.

Table 2.
Student ML1’s Start to the Equal Sharing Candy Bar Problem

<table>
<thead>
<tr>
<th>Time</th>
<th>What Was Said</th>
<th>What Was Written/Done</th>
<th>Screenshot</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00-0:30</td>
<td>Three children want to share 10 candy bars so that each child gets the same amount. How many candy bars would each child get? So there’s 3, 3 and the 10 that we’re using, candy bars, and we’re going to split them.</td>
<td>Used pen to write the 3 and then the 10 next to it. Then drew the line between them when she said, “we’re going to split them.”</td>
<td><img src="image" alt="Screenshot" /></td>
</tr>
<tr>
<td>Time</td>
<td>What Was Said</td>
<td>What Was Written/Done</td>
<td>Screenshot</td>
</tr>
<tr>
<td>--------</td>
<td>-------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>0:30-0:46</td>
<td>So three, six, nine, so what we could do is you could do, three, six, nine and that’s minus, down one.</td>
<td>Used pen and wrote out the numbers when she counted them out loud the second time. She then wrote the negative one when she said, “that’s minus, down one.”</td>
<td></td>
</tr>
</tbody>
</table>

When she realized that 3 groups of 3 would only use up 9 of the 10 candy bars, she changed her solution strategy and it was unclear why she did so.

When she finished, I used the rewind function to revisit her original strategy to see if she would elaborate on her solution.

I: Can you tell me a little about your, so I’m going to come back to this part here. *(Using the rewind function, I returned to the very beginning of the screencast.)* So I know where those numbers came from, those were the numbers from the problem, so you wrote those out, then you counted by threes here. So what were you doing there?

ML1: There was 3 candy bars so you would have to split them, so I did, I counted by 3s all the way up to see if it would equal right away 10. But it didn’t and then I figured it was down by one so I did minus 1.
I: So that minus one, what’s that minus one?
ML1: It means like down by 1 and then I knew that that won’t work because it’s 9 not 10. *(Student ML1 Audio Transcript, July 29, 2013)*

Although student ML1 could have given this explanation had I just used paper and pencil, she was very focused on the second solution strategy that she used which included cutting the candy bars in half. I felt that by using the rewind function, she was able to step away from what she was thinking, relive the first strategy again, and try to reflect on it.

Unfortunately, just watching the screencast did not prompt student ML1 to revise her thinking. However, it did allow a better sense of what her notations represented on the screen and how she thought about the problem.

The affordances of the use of the playback function were actualized in this investigation in several ways.

First, some evidence shows that when students listened to their own screencasts, they increased their positive disposition. Students in this study were eager to listen to themselves and three students were disappointed when the function was not working properly. Because I did not control or test for students’ self-efficacy in this investigation, further research will need to be conducted to determine if students’ sense of self-efficacy increases by reviewing their screencasts.
Second, although it only occurred on three occasions, revising of strategies did occur after students watched their screencasts. As mentioned previously, research has shown (Roscoe & Chi, 2004; Rittle-Johnson et al., 2008) that having an audience or explaining to others promotes learning and having someone live to explain to promotes more sense making. It seems, however, that the data from this investigation would suggest that the mobile technology was a proxy audience and its use could promote learning and sense making. Again, as with the self-efficacy, learning was not tested and would need to be investigated in the future.

Third, the use of the playback function promoted discussions between the students and us. Because the majority of the students did not verbalize that they noticed an error in their screencasts or explanations, I tried to use the rewind option to review students’ work and go back to particular spots in their screencasts to ask questions and get students to elaborate on their thinking at those spots. This option could be an additional method for teachers to investigate students’ mathematical thinking particularly if they were unable to follow students’ explanations.

CONCLUSION

With the use of these tools and functions made available by this app, students had the capability of producing screencasts that achieved the higher levels of the SAMR Model (Puente, 2013). Because students were given the opportunity to listen to their screencasts after they recorded them, except for the first round of interviews in Florida, this already placed the task at higher levels of the SAMR Model. What the students did with their screencasts after this was up to them and added to the transformation of the task. Rather than simply solving the problem and providing an answer, students had the opportunity to develop rich media, continually engage in the problem solving, increase their dispositions as learners, and promote reflection of their own mathematical thinking. Although some of these tools and functions were possible without the technology, having them all in one app and at the students’ fingertips opened up possibilities that were unavailable or cumbersome to achieve before the technology. I am not suggesting that the technology is the driver/shaper of activity, but rather the interaction between the people, practice, and technology yield opportunities to reorganize social practices around where the action is in students’ practice. However, the technology did capture students’ entire problem solving process, which then allowed for certain discussions to occur which would not have been possible without the technology.

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REFERENCES


