Technology-Mediated Dot Talks

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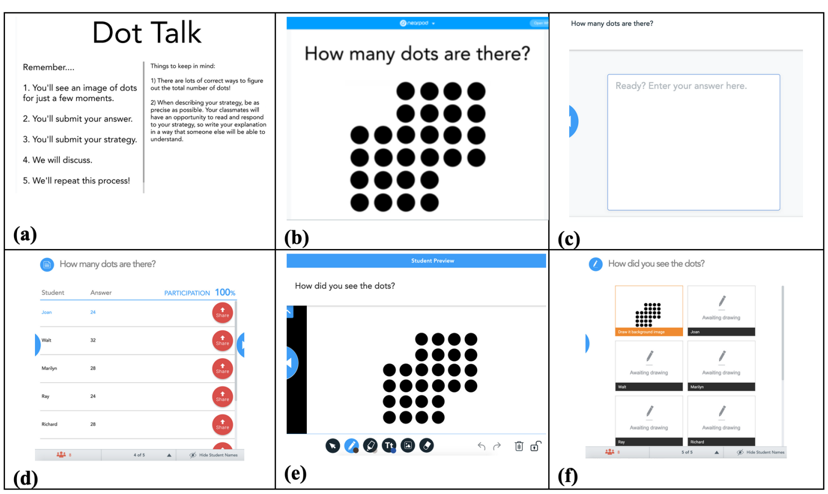
Abstract: *Visual Dot Card Number Talks are a classroom routine which allow students to recognize patterns, build number fluency, and consider others' thinking. We explicate the use of technologies–Nearpod and Desmos–for Dot Talks reimagined for use in virtual, hybrid, or in-person settings.*

Keywords: *number talks, dot cards, number fluency, technology*

Introduction

In Mr. McBeth's grade 7 mathematics classroom, all students joined Nearpod on their own devices. Mr. McBeth checked the live student list until everyone had joined and advanced to an introductory slide (Figure 1a). "Alright, we're ready. Let's go. We're doing a Dot Talk today to start class. In a moment, you're going to have a limited time to see the dots. Figure out how many there are, and then type in your answer when the slide appears. Remember, you won't have time to count the dots, so think about how you'll figure out how many without counting each," Mr. McBeth said. After a few moments viewing the dot image (Figure 1b), students typed their answers (Figure 1c); Mr. McBeth monitored their answers and the class progress in real time (Figure 1d). "Okay, all answers are in," Mr. McBeth said as he changed the slide. "On the slide you see now, tell me how you saw the dots" (Figure 1e). Students were then given time to record their strategies for this technology-infused Dot Talk, while Mr. McBeth was able to, again, monitor in real time (Figure 1f).

Figure 1: *(a) Dot Talk Instructions; (b) Dot Talk Image and Prompt; (c) Slide for Student Answers; (d) Teacher Monitoring Answers; (e) Slide for Student Strategies: and (f) Teacher Monitoring Strategies.*



Dot Talks

One variation of Number Talks is visual dot card talks. Number Talks are short, 10 to 15- minute classroom conversations structured to engage students in mathematical sense making and communication practices (Humphreys & Parker, 2015; Parrish, 2011). In a Dot Talk, the teacher engages students around different ways of quickly counting the number of dots (or other images) presented in a pattern. For instance, Mr. McBeth gave his grade 7 students a configuration of 28 dots (Figure 1b). After eliciting the total number of dots students saw in the image (Figures 1c, 1d), the conversation then turns to focus on different strategies students used to determine the number of dots (Figures 1e, f). Although Mr. McBeth's Dot Talk contained the general structure of a traditional Dot Talk, certain elements of the routine had been modified using Nearpod. In this paper, we will explore these and other modifications that are possible by using technology.

Number Talks support mental computation, provide an opportunity to engage in mathematical discourse, and develop students' number and operations reasoning (Parrish, 2011). The goals of Number Talks align with *Common Core State Standards for Mathematics Standards for Mathematical Practice* (CCSSI, 2010) and *Principles and Standards for School Mathematics* process standards (NCTM, 2000). Specifically, Number Talks provide students with opportunities to "reason abstractly and quantitatively" (SMP2) by thinking flexibly about numbers and number operations; "construct viable arguments and critique the arguments of others" (SMP3) through engaging with other's ideas and forming conjectures based on patterns noticed in problems; and "attend to precision" (SMP6) through the language used to describe their strategies.

Number Talks also provide an opportunity for teachers to build their capacity for eliciting and responding to students' mathematical thinking. Student mathematical thinking has become an important instructional focus as we work to improve student learning (NCTM, 2000). As teachers engage in Number Talks, they have an opportunity to ask questions to elicit and respond to student ideas, to re-present student thinking in writing, and to facilitate interactions between students so to engage with each other's mathematical ideas. Each of these aspects allow teachers to improve their practice by becoming more responsive in the moment and with instructional decisions based on their students' mathematical thinking.

Humphreys and Parker (2015) argue that Dot Talks are an appropriate way to introduce students at all grade levels to the Number Talk routine as students will naturally see different patterns within a dot picture and the dot patterns are less likely to evoke negative emotions related to prior arithmetic experiences like speed drills. Dot Talks help establish productive norms for this classroom routine: "there are many ways to see, or do, any problem; everyone is responsible for communicating his or her thinking clearly so that others can understand; and everyone is responsible for trying to understand other people's thinking" (Humphreys & Parker, 2015, p. 14).

A Reimagined Routine

This article describes two different technology tools—Nearpod and Desmos—teachers can use to modify (Puentedura, 2013) the traditional Dot Talk routine. That is, we show how the technology allows for significant task redesign, including enhancements that would not be possible without the use of technology.

Traditional Dot Talk Routine

A traditional Dot Talk (or Number Talk) routine follows five core elements (Matney et al., 2020). First, the teacher displays the dot card. If the object is to not count each dot one-by-one, then the teacher may limit the time the dot card is seen by students. Second, students mentally compute the total of dots. While waiting for the peers to do the same, they can challenge themselves to think of multiple ways to describe how to "see" the dots without counting them individually. Often, students use hand signals to indicate they have an answer (a thumbs up) and the number of solution strategies they have found (a finger for each). Third, the teacher requests answers, recording them on the board; hand signals can be used to tell the teacher if there is agreement or dissension. Fourth, the teacher requests strategies, again recording them on the board. Here, students describe the ways they saw the dots to determine how many were there. And finally, the teacher "connects student thinking to the mathematical goal" (Matney et al., 2020, p. 2). The goals may include supporting students to begin engaging in the mathematical practices, to write expressions to represent the solution strategies, or to recognize patterns.

Modifications Afforded by Technology

Each of the core elements of the Dot Talk routine can be modified with technology. In Table 1, we outline modifications that are possible with the use of technology.

Table 1: *Dot Talk Routine with Technology.*

Element	Possible Enhancements with Technology
1: Problem	• Pace: *Dot image can be displayed for pre-determined time, set on a timer.* • View: *All students can see the image from the same distance/angle on their devices.* • Setting: *Students can participate from the classroom as individuals or in small groups, or from remote locations with an internet-connected device. Video capability is not required.*
2: Computation 3: Answers 4: Strategies 5: Connections	• Progress Monitoring: *The teacher can set the answer screen or strategy screen to a timer so students record their thinking in the given time. Additionally, the teacher can observe student progress in real time as students are working or after they submit their work.* • Recording Answers: *Students can type or write in the number of dots they saw on the screen.* • Recording Strategies: *Students can draw directly on dot image to show how they counted the dots then submit the image to the teacher for the repository. Teacher can also elicit a written explanation of how the students counted the dots.* • Displaying Answers and Strategies: *Teacher can display a visual of all answers as a collective or pick and choose answers from the saved repository to share after quickly scanning the submitted answers. Similarly, strategies can be selectively chosen to share, sharing one or more at a time for comparison. Answers and strategies can be displayed with or without student names attached.* • Discussion: *Teacher can ask authors of answers and strategies, or another student, to discuss the displayed ideas. Teacher can highlight or add to the display as the student explains ideas.*

Different Expectations

Technology-based modifications to Dot Talks inherently change the routine in ways that shift the original expectations for teachers and students. For instance, teachers are traditionally responsible for recording student strategies in traditional Dot Talks, while students can record their own strategy in a technology-modified Dot Talk. If students in a technology-modified Dot Talk are to record their own strategies, they should be given time for mental computation before being provided with a screen to describe their thinking. A slide can show the dot display (Figure 1b), and time allowed for students to generate solutions and strategies. Then a slide to record those answers can be shared (Figure 1c), serving as an intermediate step to the original sharing out. Since students can share their strategies simultaneously using technology (Figure 1e), the teacher can quickly scan every answer without having to call on each student individually. This process also means that the teacher can assess every student's participation in the Dot Talk, making it harder for a student to choose not to reveal a different idea or just agree with a shared idea even if it differs from their own.

The shift of who is responsible for recording student strategies is one key modification of the Dot Talk routine. There are some potential advantages to this change. First, the teacher can use the repository of saved strategies to intentionally select which to show for discussion—and one or more can be displayed simultaneously. This can allow specific strategies, perhaps those that are less advantageous or that might otherwise not be shared by students to be part of the discussion. And the student author does not necessarily have to be who explains the idea, allowing a student's strategy to be shared with the class even if they are not comfortable explaining it out loud. Asking another student to make sense of the written work of a peer is a different but important task, as it involves interpreting other student's work rather than your own (CCSSO, 2010; NCTM, 2000). Finally, since technology allows students to draw their strategy for determining the number of dots directly on the image, the teacher does not have to determine how to record their work on the board, which can be challenging.

With the use of technology, the pacing and setting can vary. For instance, Nearpod and Desmos allow students to work on the Dot Talk at their own pace or at different times outside of the school day. When the Dot Talk is done partially or completely asynchronously, like we illustrate with Desmos below, the teacher should revisit the talk during class so that students can have a discussion around the different strategies.

Examples

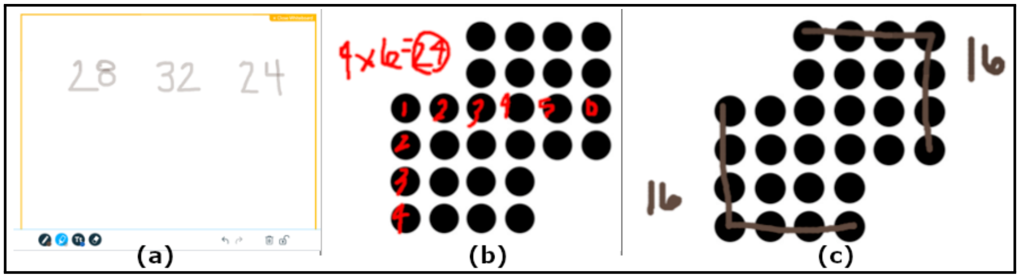
We illustrate the features of Nearpod and Desmos for use for modified Dot Talks in middle and high school mathematics teaching and learning. These specific technologies were selected because they are free, specifically designed for teaching and learning, and afford various possible modifications to the Dot Talk routine. For each, the prompts are "how many dots are there?" (Figure 1c) and "how did you see the dots?" (Figure 1e).

Nearpod

Recall, Mr. McBeth's class engaged in a Dot Talk using Nearpod. After collecting solution strategies, as illustrated in the opening vignette, Mr. McBeth said, "Okay. All of your strategies are in (Figure 1d). Thank you. Let's go back to our answers." Then he stated and wrote each unique answer on the Nearpod whiteboard (Figure 2a). "I see 28, 32, and 24." Using the whiteboard feature through Nearpod, Mr. McBeth was able to record the submitted answers so that it was visible for students. By scanning student submissions, Mr. McBeth made sure that all answers were shared. "Let's start with 24. I see that Ray got 24, so I'm going to show his strategy and let him explain." Mr. McBeth shares Ray's slide, where he'd recorded his strategy (Figure 2b), with the class as a conversation begins. By selecting Ray to share first, Mr. McBeth ensured that an incorrect solution strategy be explored.

RAY : I first counted $1, 2, 3, 4$. And then $1, 2, 3, 4, 5, 6$.
MR. MCBETH : I see the $1, 2, 3, 4$ down the left side and the $1, 2, 3, 4, 5, 6$ across the middle. Right?
RAY : Yes.
MR. MCBETH : Okay. Keep going.
RAY : Then I did 4 times 6 which is 24.
MR. MCBETH : Thank you. I see you wrote the expression 4 times 6 equals 24 to represent your idea. Are there any questions or comments for Ray? [*Joan signals the teacher.*] Joan, go ahead.
JOAN : I did something similar, but I got 32.
MR. MCBETH : Okay. I'll put up your strategy (Figure 2c) and you can explain.

Figure 2: *(a) Teacher-recorded Answers from Students; (b) Ray's Strategy; (c) Joan's Strategy.*



JOAN : I did 4 times 4 since for the bottom square. And then 4 times 4 for the top square.

MR. MCBETH : Okay. So you saw two squares. And you did 4 times 4 for each square. How'd you get 32?

JOAN : Each square is 16. So 16 and 16 is 32.

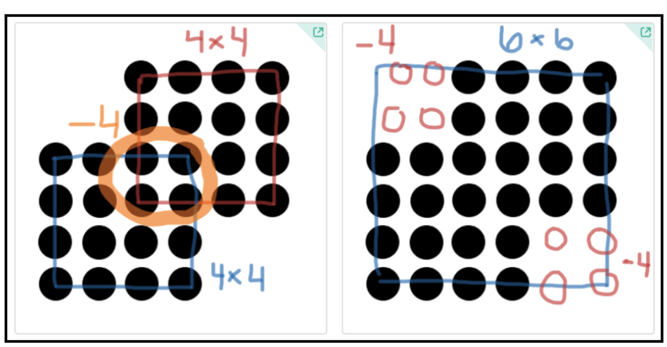
Joan and Ray's strategies were similar in that each one used an array model, though both of their conceptualizations did not account for the array not being rectangular or being a composition of arrays or rectangles. By using Nearpod, the students in Mr. McBeth's class were able to draw their own thinking that the teacher could show as the student explained.

Desmos

Both Nearpod and Desmos allow for students to complete all or part of a Dot Talk (or Number Talk) asynchronously. While teachers should have a class discussion around students' strategies, eliciting their initial ideas asynchronously could allow students to work at their own pace or shorten the class time it takes to complete the routine. In the vignette below, Ms. Rodriguez asked her high school geometry students to start a Dot Talk asynchronously as their warmup. "As you are getting settled in your seats, go ahead and log into your Desmos account and start the activity. In five minutes, we will talk about your strategies for the first two patterns listed. There are some additional prompts for you to work through if you finish early," Ms. Rodriquez directed at the beginning of class. While students work through the assigned slides, Ms. Rodriguez read their responses by clicking on each screen in the Desmos teacher tab. After selecting some to discuss as a whole class, Ms. Rodriguez used the snapshot feature to prepare slides (called collections in Desmos) to present to the class. After discussing two different students' strategies, Ms. Rodriguez showed a slide that contains images of two student strategies side by side (Figure 3).

MS. RODRIGUEZ : Now I want us to look at Robert and Micah's strategies together. What do you notice is the same and different about the way they counted the dots? Micah?

Figure 3: *Micah (left) and Robert's (right) Solutions within Desmos for the Dot Talk Image.*



MICAH : Both Robert and I counted the dots by looking for squares. I saw two squares that were 4 by 4 while Robert saw one larger 6 by 6 square.
ROBERT : Yeah. And Micah had to subtract 4 at the end because he counted the middle dots twice. I had to subtract two sets of 4 to make up for the extra dots I added in on the corners.

After a few more students described similarities and differences between Micah and Robert's strategies, Ms. Rodriguez decided to pose a challenge question for students.

MS. RODRIGUEZ : Okay, I am going to switch it up a little bit. Here is one student's written description of how they saw the dots. [*Ms. Rodriquez projects Figure 4 for the class to see.*] What image do you think they drew based on this description?

Figure 4: *One Student's Written Description for the Dot Talk Image*

> I saw two 2x4 rectangles and one 2x6 rectangle. So 8 + 8 + 12 = 28 dots.

ANGEL : If you look at the top and bottom of the picture, there's 2 horizontal rectangles that are 2 by 4. Then the 2 by 6 rectangle is in the middle.
MS. RODRIGUEZ : Okay. Did anyone think about it in a different way?
NAOMI : I did. I thought the rectangles were vertical, so the 2 columns on the right and left were the 2 by 4 rectangles and then the 2 columns in the middle was the 2 by 6 one.
MS. RODRIGUEZ : Interesting. Okay, turn to a neighbor and discuss who you think is right.

Using Desmos, Ms. Rodriguez modified the Dot Talk routine in a couple of ways. By beginning the first part of the routine asynchronously, students could work through the prompts before everyone was in the classroom. Like the Nearpod example, Ms. Rodriguez could intentionally select student work ahead of time, allowing for the class discussion to focus only on specific representations and ways of counting. The snapshot feature also enabled her to project two students' images at the same time, allowing students to make connections across the strategies. Finally, she was able to have students think backwards by going from a written description to a picture at the end of the Dot Talk. This conversation could serve to highlight the importance of using mathematically precise language (SMP6).

Modifying Your Dot Talks with Technology

While Nearpod and Desmos are all useful tools to facilitate a Dot Talk, they each allow for different modifications to the traditional routine. In Table 2, we summarize specific features of each that can be matched to the goals of your talk to guide in the technology selection.

Potential Challenges

There is the possible necessity for additional technology to accompany the use of Nearpod or Desmos for your technology-modified Dot Talk. For instance, to share strategies collected in Desmos, the teacher can use the screen capture option within Desmos to display multiple student strategies but must project those on to the classroom board or to students remotely through additional technology. This is different from Nearpod, which allows the teacher to share student work with the entire class onto individual students' screens. Students participating in the Dot Talk remotely will have to navigate between video conferencing software (such as Zoom or Google Meet) and the technology used for the Dot Talk. Unlike traditional Dot Talks, where the teacher uses the board and organizes answers and strategies that can stay in view throughout the talk, the use of the technologies does not allow for the same constant display.

Table 2: *Affordances of Technologies for Dot Talk Routines.*

	Nearpod	**Desmos**
Google Slides integration	✓	
Student login options	Code Google Office 365 +more	Code Google Desmos
Requires student Google account		Optional
Requires teacher account	✓	✓
Compatible with Google Classroom	✓	✓
Options for displaying student work: anonymously, with student name	Both	Both
Student work can be saved for future reference	✓	✓
Can access student work after talk, by student	✓	✓
Teacher can set pace to allow students to work ahead		✓
Teacher can set timers to control how long students have on a slide	✓	
Teacher can see student progress in real time to monitor responses	✓	✓
Students submit or lock in answers	✓	✓
Students can write directly on the dot image	✓	✓
Teacher can select and sequence because they can see all strategies before they start sharing with the class	✓	✓
Student answers/strategies can be shown to students without additional technology	✓	
More than one student strategy can be shown at a time		✓
Student slides can be used for connections, showing three randomly selected peers' strategies for comparison		✓
An asynchronous form of the dot talk could be done	✓	✓

Planning Resources

To further support implementation of modified Dot Talks, we provide a template Dot Talk in each technology we have discussed. To view the Dot Talk as we intend a student would, see https://share.nearpod.com/sM1UdBb14hb. A Nearpod template (https://share.nearpod.com/e/t7LsuBKP4hb) will create your own editable copy in your own Nearpod account which you can amend for your own Dot Talk. You can view the Desmos template using the link provided (https://teacher.desmos.com/activitybuilder/custom/5fb4164d12f9a235f3d23b42?collections=5fb4162cc874ee0b0c427932). You will need a Desmos account in order to edit and use this template as your own.

Concluding Thoughts

Although the expectations of modified Dot Talks are different from a traditional Dot Talk, the enhancements with technology still allow the routine to maintain focus on students' conceptual understanding and procedural fluency. We focused on Dot Talks in this article because we found the ability for students to draw on top of the images to make it easier to share and discuss their strategies; however, the use of technology to modify the routine can also be used with Number Talks. Further, Dot Talks are accessible across late elementary through high school, and we demonstrated the use of the same visual dot card in a grade 7 and a high school geometry setting. The use of technology-modified Dot Talks not only can introduce students to the Number Talk routine, but also to the technologies. Nearpod and Desmos can be used for much more in the mathematics classroom! Additionally, while the modification of Dot Talks with technology can be implemented in face-to-face settings, these technologies can be used in virtual and hybrid settings, synchronously and asynchronously. Modifying Dot Talks with technology which can allow for virtual and asynchronous mathematics teaching and learning is an additional affordance.

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