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Providing Virtual Mathematics Feedback: Connecting Research to Practice

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Abstract

Feedback is an essential form of communication between the student and teacher. Research has documented the importance of feedback in advancing student mathematical and critical thinking, with renewed recommendations to provide and use feedback in mathematical instruction during the era of COVID-19. Giving personalized feedback in an online environment can be a challenge – especially in a mathematics class. This article summarizes five core principles of feedback, associated strategies for mathematics teachers to provide students virtual feedback, and notes on how we have implemented these strategies in middle school mathematics classes.

Keywords

feedback, mathematics, online, virtual

The abrupt transition to virtual learning caused by COVID-19 in 2020 upended education (Martin, 2020), as students and teachers were thrown into the digital world without adequate time to skills to match the new learning environment. One challenge included providing students meaningful feedback in a virtual environment, especially in reasonable ways for teachers responsible for 150 or more students. Feedback can be defined as thoughts or information shared with students to help them learn and grow in their understanding of the content being taught (Burke & Pieterick, 2010). Research has documented the importance of feedback in advancing student mathematical and critical thinking, with renewed recommendations to provide and use feedback in mathematical instruction during the era of COVID-19 (NCSM and NCTM Joint Statement, 2020; Perego, 2020). To better our own digital feedback, we explored research-based recommendations for providing virtual feedback to middle and high school mathematics students. This article summarizes five core principles of feedback (Figure 1), associated strategies for mathematics teachers to provide students virtual feedback, and notes on how we have implemented these strategies in middle school mathematics classes.

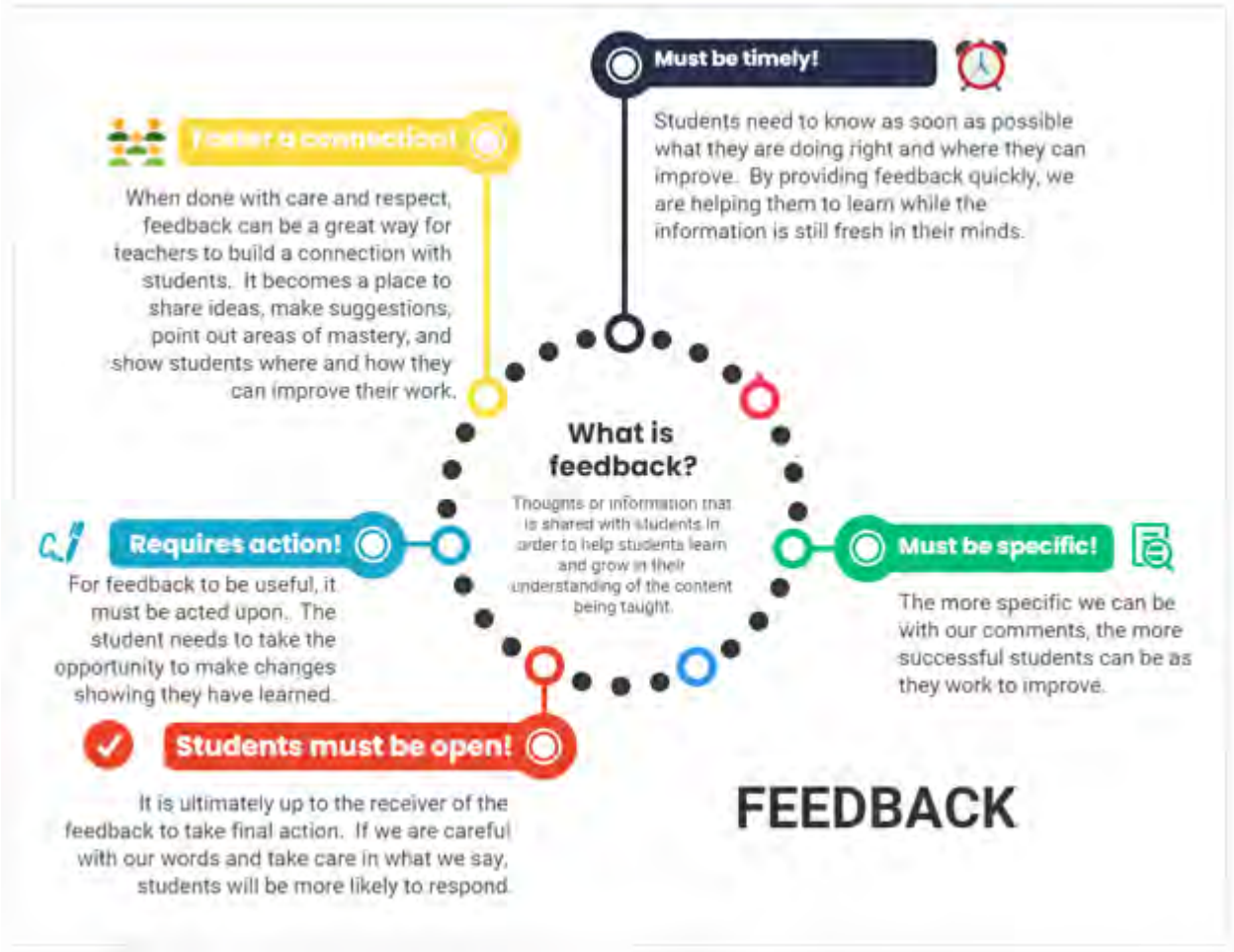


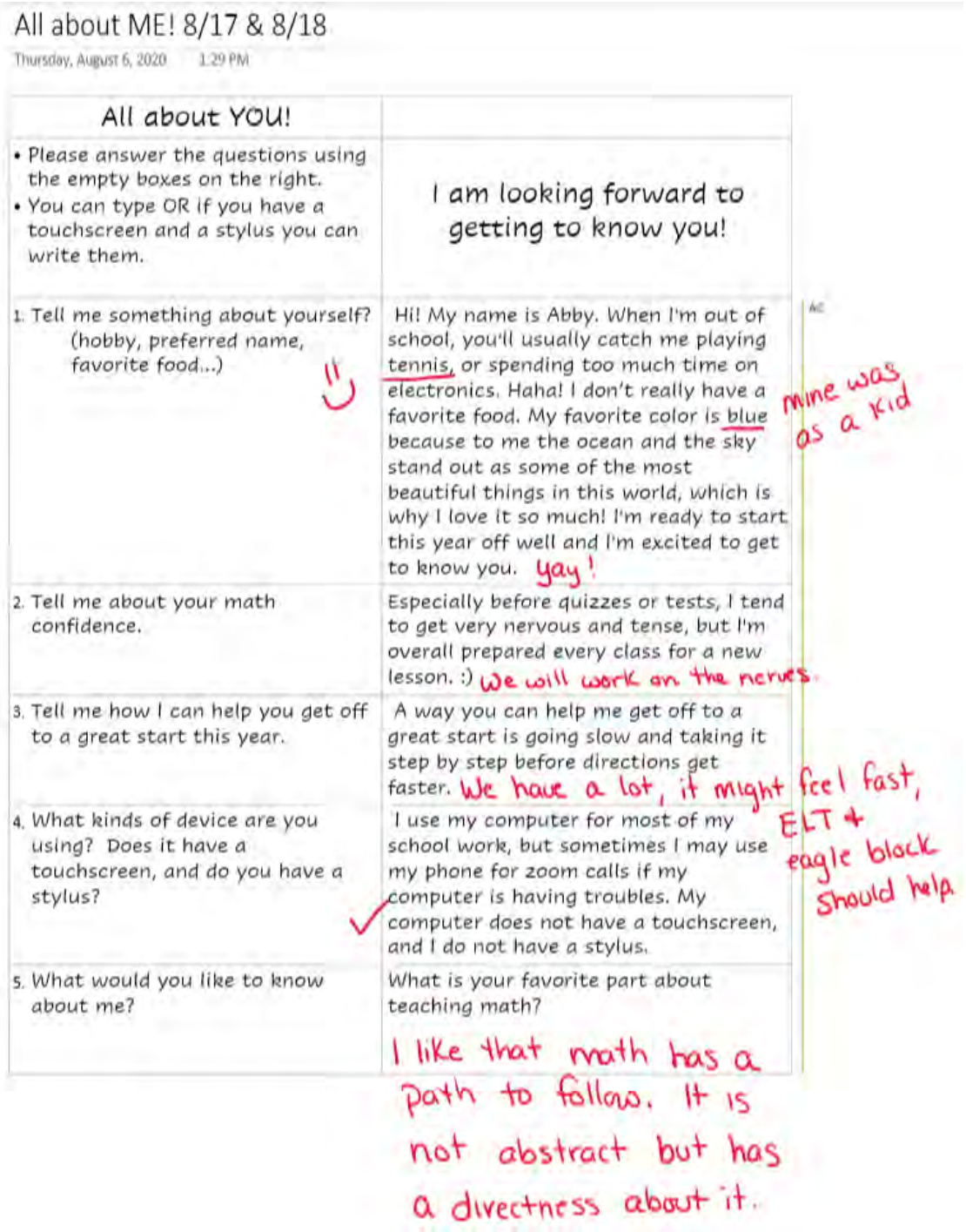
Figure 1: Summary of feedback principles (Burke & Pieterick, 2010; Sull, 2019; Wiggins, 2016) that we found most applicable and important to providing digital feedback in mathematics.

Foster a Connection

Feedback should be engaging and motivating to students (Burke & Pieterick, 2010). Teachers can monitor their students to find out if they understand the feedback by asking them to answer back comments in order to find out that they understand what to do next.

Application in Our Virtual Classrooms: To initiate interest and learn about our students, we started the year with a questionnaire. We asked students a few

questions about themselves and invited them to ask us questions as well. Since we were working digitally, students typed their answers in our Class Notebook (part of OneNote, free for Microsoft 365 users) and we were able to go in and handwrite our replies to their questions as well as evaluate written mathematical work (Figure 2). We thought providing students the opportunity to see the instructors' handwriting would give them the personal touch that can be lost in a digital teaching and learning environment. Students were able to read feedback, and only their feedback, as soon as we posted it within Class Notebook.



All about ME! 8/17 & 8/18

Thursday, August 6, 2020 1:29 PM

All about YOU!	
• Please answer the questions using the empty boxes on the right. • You can type OR if you have a touchscreen and a stylus you can write them.	I am looking forward to getting to know you!
1. Tell me something about yourself? (hobby, preferred name, favorite food...)	Hi! My name is Abby. When I'm out of school, you'll usually catch me playing tennis, or spending too much time on electronics. Haha! I don't really have a favorite food. My favorite color is blue because to me the ocean and the sky stand out as some of the most beautiful things in this world, which is why I love it so much! I'm ready to start this year off well and I'm excited to get to know you. yay!
2. Tell me about your math confidence.	Especially before quizzes or tests, I tend to get very nervous and tense, but I'm overall prepared every class for a new lesson. :) We will work on the nerves.
3. Tell me how I can help you get off to a great start this year.	A way you can help me get off to a great start is going slow and taking it step by step before directions get faster. We have a lot, it might feel fast,
4. What kinds of device are you using? Does it have a touchscreen, and do you have a stylus?	I use my computer for most of my school work, but sometimes I may use my phone for zoom calls if my computer is having troubles. My computer does not have a touchscreen, and I do not have a stylus.
5. What would you like to know about me?	What is your favorite part about teaching math?

mine was as a kid

ELT + eagle block should help

I like that math has a path to follow. It is not abstract but has a directness about it.

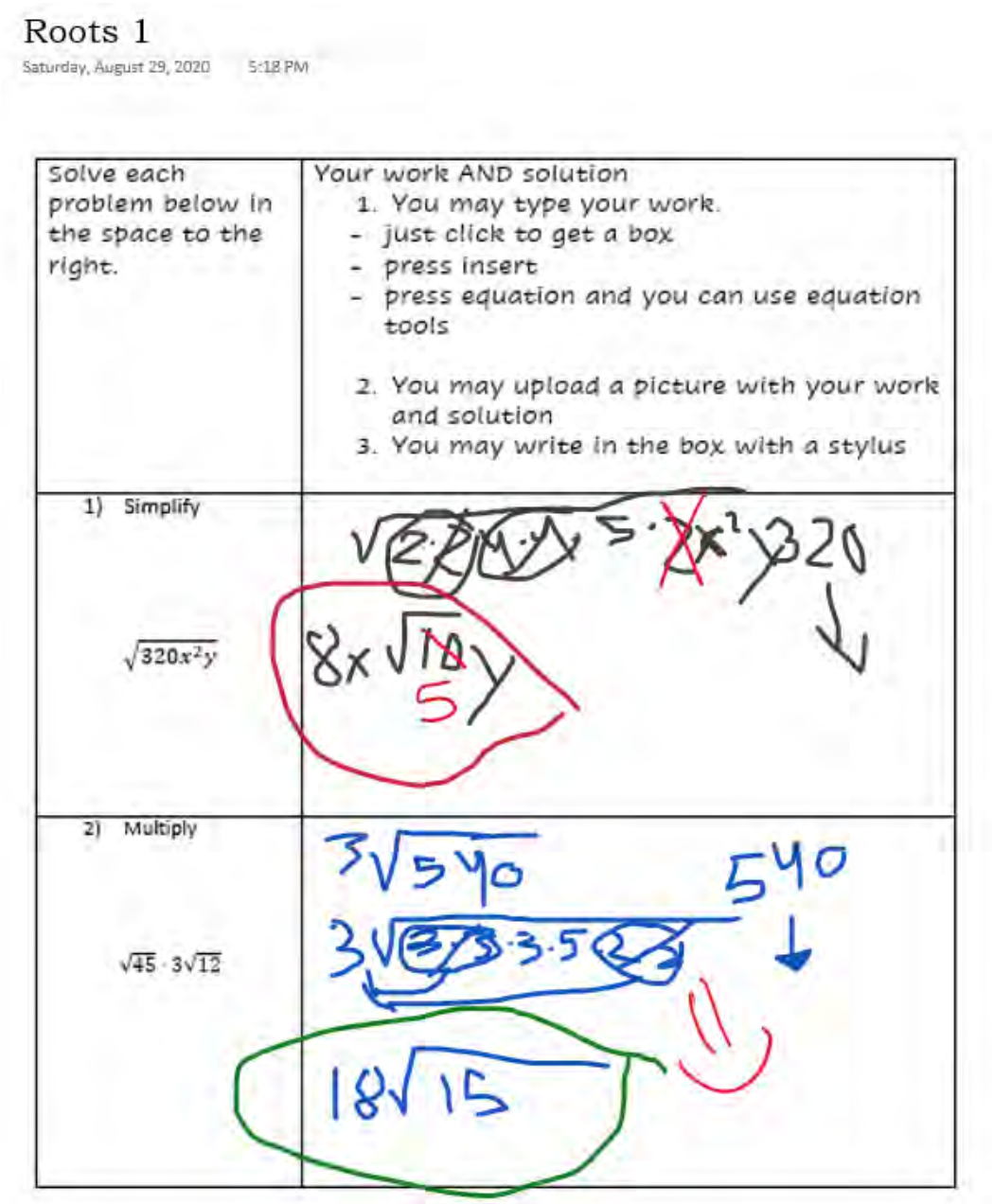


Figure 2: Examples of digital feedback provided through Class Notebook that fostered connections by engaging and motiving students with encouraging comments that were handwritten and including written emotions.

Implementation notes:

- *Type*: Asynchronous feedback to **Foster a Connection**
- *Technology needed*: Class notebook (part of OneNote, free for Microsoft 365 users), computer or tablets
- *How*: Send the page with questions electronically to students' individual notebooks. They respond and return to the instructor, who can then answer questions and made comments, trying to show interest through own handwriting.
- *Ease of Use*: Very easy. We can open student work on a tablet and write directly on each student's page.
- *Time needed*: Little. It takes about the same amount of time to go through student work as evaluating work on written paper.
- *Problems*: Some, as not all students complete work and it is harder to follow up on in the digital environment.
- *Other feedback methods to support fostering connections when teaching mathematics virtually*:
    - Reciprocal peer using tablets (Yang et al., 2016) or Desmos (Joyce, 2016)
    - Math Learning Center apps to make student thinking visible (Tamargo & Johnston, 2019)

Must be Timely

Feedback should be delivered when the students are engaged with the work so students can make improvements (Burke & Pieterick, 2010). "This involves both how soon feedback is given (typically, earlier is better) as well as how often (typically, more frequently is better)" (Ambrose et al., 2010, p. 142).

Application in Our Virtual Classrooms: Since we met with our students synchronously (at the same time), we provided timely feedback to students during these virtual meetings. One way we do this is through the polling feature on Zoom, where students are asked to respond to a question and summary results can be displayed without holding individual students accountable to their answer (Figure 3). This method works great at the beginning of a synchronous lesson (reviewing previous concepts, priming students for new material), in the middle of a lesson (coming to a consensus on what was said), or at the end of a lesson (summarizing or applying what was just learned). Most teachers already weave in formative assessments in our classrooms in the form of warm-ups and exit tickets – our suggestion is to find ways using your school's platform to integrate these practices virtually. Asynchronously, you can set up virtual quizzes within your learning

management platform that automatically assess and give specific feedback based on student responses (Figure 4).

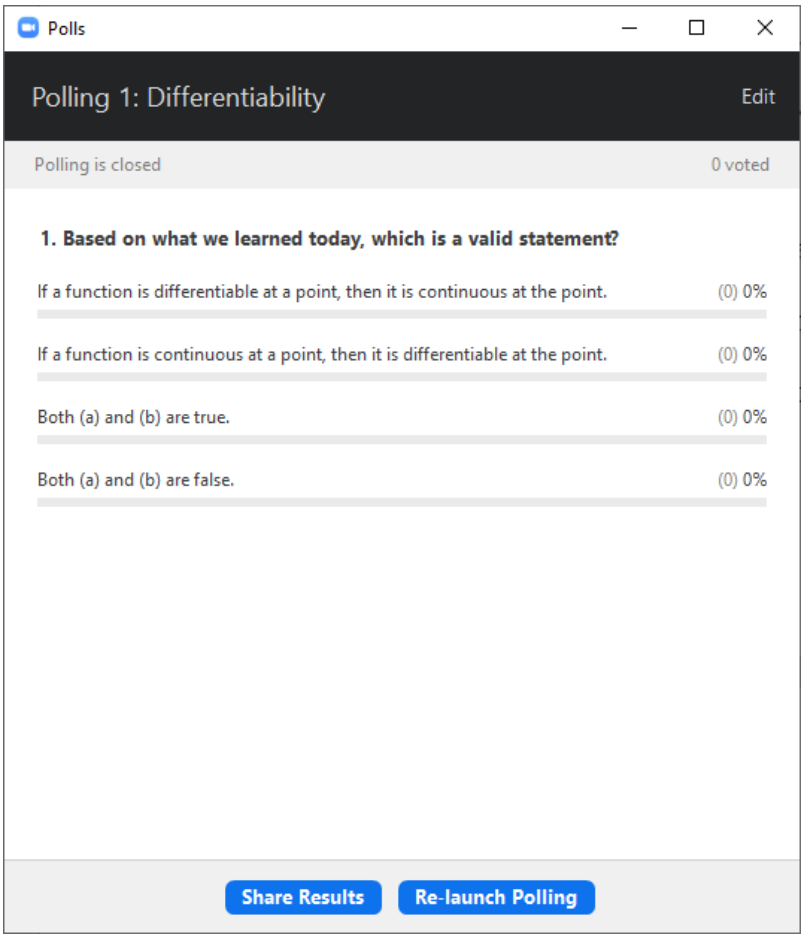


Figure 3: Using polling to provide students timely (immediate) feedback during a lesson.

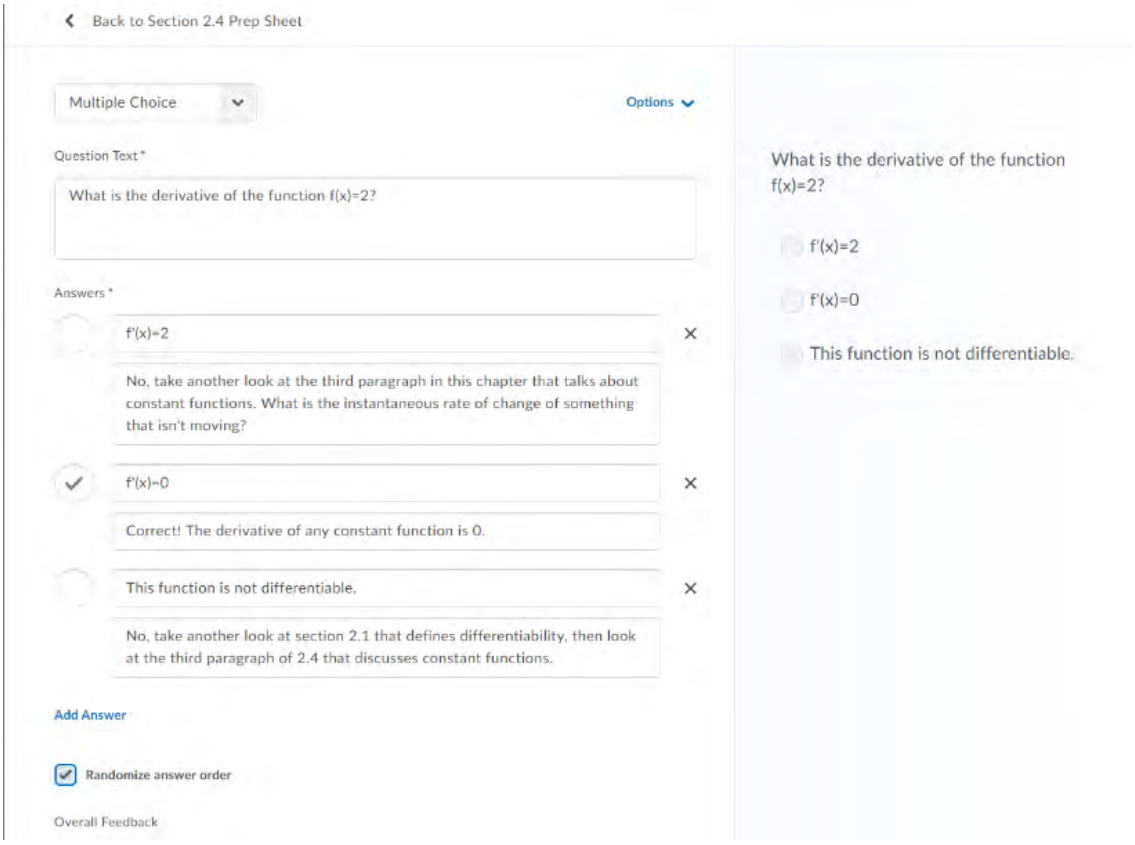


Figure 4: Using the Quiz feature within our learning management platform to set up tailored and immediate feedback to students.

Implementation notes:

- *Type*: synchronous or asynchronous feedback to provide **Timely Feedback**
- *Technology needed*: whatever platforms you are already using to teach your classes both synchronously and asynchronously.
- *How*: Set up the quiz or poll before the class or assignment, then provide verbal feedback or pre-written feedback in response to their answers.
- *Ease of Use*: Very easy. Most learning platforms have ways to create polls and quizzes with multiple choice answers.
- *Time needed*: Little. It takes a few minutes to set this up, but almost no time to actually provide the feedback. Especially beneficial if you have large classes.
- *Problems*: Rare. A student every now will have problems in the learning management platform.

- *Other methods to provide timely feedback when teaching mathematics virtually*:
    - Integrating Desmos to provide students immediate feedback (Hampton, 2019).
    - Recorded video, specifically Voice Thread (Ching & Hsu, 2013), or a class Wiki (Yuan & Kim, 2015).
    - Using math online learning systems to provide students feedback (Inventado et al., 2017), including Socrative (Yenca, 2016).

Requires Action

Feedback should provide students with concrete, specific, useful, and actionable information (Wiggins, 2016). Actionable feedback tells the learner what is needed to meet the goal, along with supporting information or resources (Burke & Pieterick, 2010; Ambrose et al., 2010).

Application in Our Virtual Classrooms: Taking action on feedback in our classes often requires the student to rework a problem, complete a similar problem, revisit class materials to better understand a concept, or challenge the student to consider something new. We try to always answer: will students know what to do with our feedback?

Asynchronously, we support actionable feedback by taking time to provide detailed responses to daily quizzes, which we sometimes call prep sheets; in Figure 4 you can see how we provide automated feedback that direct learners to (re)consider information if they answered incorrectly and what resources can be used to correct the problem. Even if the student answered correctly, we try to include information that helps summarize patterns. We sometimes include links to Desmos pages, GeoGebra sketches, or instructional videos to help students have information, scaffolding, and resources to correct their response. Most importantly, we offer students two attempts when completing the prep sheets, so they have an opportunity to correct their errors, providing motivation to read and follow-through with the actionable feedback. Figure 5 shows a summary email we sent to all students detailing the actions expected following feedback on one of their assignments, along with opportunities to improve their performance on the assessment.

Hello my fabulous algebra students (and parents)!

I hope you are doing well this Wednesday morning. I just wanted to let you know that I have finished grading your Unit 2 math test, I have provided some feedback to you in the form, entered your grades, and returned the test form to you. This is what I need from you please.

1. Go into the form and see what questions you missed, and read any feedback
2. If you earned below an 80% you will have an opportunity to do a retake on the test for a maximum new score of 80%.
- Start planning now by reworking missed questions (if you can find your mistake you likely won't make it again)
- Make a list of questions for me
- Plan to come to ELT next Wednesday so we can work on areas you need help with
3. The will be a retake after Thanksgiving break. My general observations:
- we need to work on slope and understanding how that controls a line
- we need to practice solving

Overall - great job!

Let me know if you have questions or need help with a plan moving forward to improve! You are all rockstars and can do this!

[Teacher signature]

Figure 5: The email we sent to a class following a large unit test, detailing the specific actions students should take in response to the feedback given.

Implementation notes:

- *Type*: asynchronous feedback that **Requires Action**
- *Technology needed*: whatever platforms you are already using to teach your classes asynchronously.
- *How*: Incorporate concrete, specific, and actionable information in the automatically evaluated responses to regular asynchronous quizzes, incorporating external and even interactive resources to support students.
- *Ease of Use*: Easy. Don't forget to change the settings to allow a second attempt.
- *Time needed*: Little to moderate. It takes a few minutes to write up actionable feedback for each response, but the automated part helps especially if you have large classes.
- *Problems*: Rare. Some students will not read the feedback.
- *Other methods to provide actionable feedback when teaching mathematics virtually*:
    - Using Edmodo, Kahoot, and Socrative (Gay & Burbridge, 2016)
    - Test revision strategies from Brown (2005) that could easily be applied to virtual settings

- Providing targeted feedback in mathematics classrooms (Small, 2019) by using virtual assessments that are meaningful and advance student understanding

Students must be Open

Feedback should be received by one who is present with an attitude of acceptance. Teachers can provide feedback in a variety of ways but if a student is not open to receive, think about, and act on the feedback, it remains ineffective (Burke & Pieterick, 2010).

Application in Our Virtual Classrooms: Preparing students to be open to feedback involves thoughtfully attending to tone and developing shared understandings between teacher and student (Weaver, 2006; Lipnevich, Berg, & Smith, 2016). Conveying tone and understanding is challenging in virtual learning environments, so we try to use instructor presence and classroom community to create spaces where students become more open to receiving feedback (Glassmeyer, Dibbs, & Jensen, 2011).

Asynchronously, we try to make a weekly post highlighting something that happened in class, perhaps linking to a discussion post, sharing a screenshot of a student's mathematical solution, the revision or correction of a problem, or a great question someone asked that week. For example, Figure 5 shows a supportive email that, in addition to giving actionable feedback, helps create a shared understanding of what is important in the class as well as a supportive tone. We try to provide opportunities for students to consider and incorporate feedback into further practice, sometimes by correcting the problem or solving similar problems. We think highlighting this process in an announcement where students' names are blocked out can support students to being open toward receiving feedback. This helps convey feedback as a supportive, ongoing process as well as supports students benefitting from the feedback (Ambrose et al., 2010). Synchronously, we spend a few minutes before class chatting with students and are mindful of ways to show we care about the students and the course material; to be honest, these tactics are things we do normally face-to-face, and virtually we just have to be intentional about creating a few moments to continue sharing these important moments as emotional connections that can support students to be open to feedback we give.

Implementation notes:

- *Type*: supporting students to be **Open** to asynchronous and synchronous feedback

- *Technology needed*: whatever platforms you are already using to teach your classes
- *How*: Consider the tone in which feedback is given and developing shared understandings of what is important in the course
- *Ease of Use*: Can be difficult to do consistently
- *Time needed*: Moderate.
- *Problems*: Common. Changing student perception of feedback takes time and continual work and may require additional support, such as contact with parents/guardians or assistance from counselors.
- *Other methods to promote students being open to virtual feedback:*
    - Video-based feedback to message students directly (Henderson & Phillips, 2015)
    - Using discussion boards (Klein et al., 2016) or dynamic graphing software (Joyce, 2016) to create opportunities to provide peer-to-peer feedback

Must Be Specific

Feedback should be purposeful and offer detailed information for students to learn the desired concepts. Specific feedback does not necessarily mean giving the correct answer to a problem missed, but open dialogue between student and teacher and give students ideas to reflect on (Burke & Pieterick, 2010).

Application in Our Virtual Classrooms: With some adjustments, providing specific feedback virtually is not all that different than doing so face-to-face. Building on the strategies described earlier, we have found using inking to mark directly on student work (Figure 2) clearly indicates where mathematical errors occur, supporting specific digital feedback. Setting up immediate feedback through automatically graded quizzes (Figure 4) can also give specific feedback about students conceptual understands, for instance clarifying definitions, overarching concepts, and mathematical generalizations. Synchronously, we use screensharing that includes showing of our mouse to point as we provide live feedback to students. Similarly, encourage students to use visuals when providing each other feedback through screensharing that includes the mathematical work and a pointer or marker to direct the viewer's attention to what is being discussed. These visual cues mimic the interaction occurring face-to-face with hand gestures toward the board or work written on a paper. Specifically indicating where a student lost a negative or made an arithmetic error can help notice and learn from their mistake.

Implementation notes:

- *Type*: asynchronous and synchronous **specific** feedback
- *Technology needed*: whatever platforms you are already using to teach your classes
- *How*: indicate precisely any kinds of error (conceptual, arithmetic, etc.), where they occurred, and what students could reflect upon to improve their understanding of the concept
- *Ease of Use*: Easy, usually small modifications
- *Time needed*: Usually little.
- *Problems*: Rare, though some students will not read the feedback
- *Other methods to help provide students specific mathematics feedback:*
    - Using rubrics to provide students feedback (McGatha & Darcy, 2010), then incorporating the rubric into your course management system.
    - Creating and using detailed expectations for group work and classroom discourse (Baron, 2016) and applying them within synchronous course meetings

Conclusion

Summarizing every research-based recommendation for providing virtual feedback to middle and high school mathematics students would be impossible, but we have found the five strategies outlined above effective in our virtual mathematical instruction, by providing student-connected, timely, actionable, openly-received, and specific feedback. As we navigate continued instruction digitally, we look forward to improved and novel ways to provide students effective feedback in our classrooms.

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