Thoughts on Attending to Student Thinking During COVID-19

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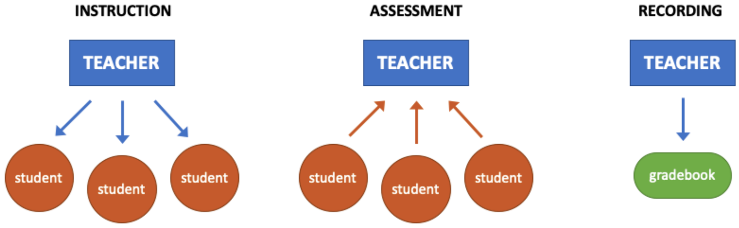
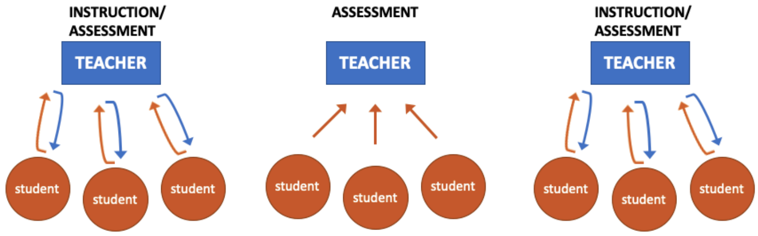
In this session we will focus on the practical aspects of K-12 teaching during COVID. My focus will be on how teachers can adjust the best practices of a mathematics classroom to accommodate remote and in-person simultaneous students and social distancing while still attending to student thinking. Traditional distance learning (with text or videos) focuses on a one-direction model of instruction where content is delivered and the students consumes, and does not allow for teacher-student interaction that focuses on how students are thinking. The teaching acts of building a model of a student's thinking, testing and refining that model, and adjusting instruction accordingly are already difficult in a traditional in-person class. I will be sharing my own experiences of teaching digitally while still attending to student thinking. Adjustments in teaching, gathering feedback, and managing technology and physical materials will be discussed. The session will end with the audience invited to share how they are attending to student thinking in their classrooms during COVID.

The COVID-19 pandemic has caused the first large-scale shutdown of in-person schooling in the United States in the Internet age (Decker 2020). Predictably, a lot of instruction has shifted to synchronous (live) and asynchronous (pre-recorded) online teaching. Some schools are using methods such as split cohorts and hybrid schooling to allow students to come to school some of the time while reducing the number of people in a room to allow for appropriate social distancing. As schools and teachers adjust to this new reality, it is easy to fall back onto a traditional image of schooling where the teacher imparts knowledge (instruction), the students show the teacher what they remember (assessment), and the teacher records that information (grading) before moving on to a new cycle with new information. This image of schooling fits well with the idea of a pre-recorded or live lecture followed by homework completed with minimal teacher help. Unfortunately, since most online learning in the U.S. before COVID-19 was asynchronous, this expectation for online learning was already set.

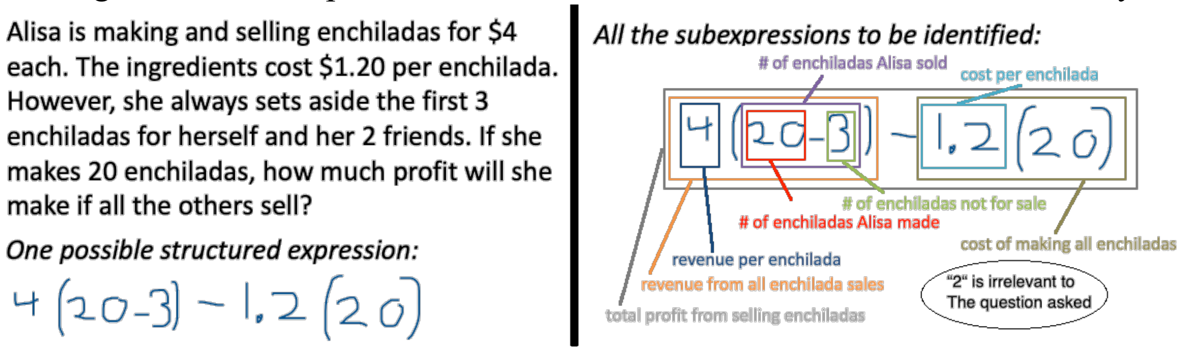


However, synchronous teaching gives us the possibility to treat instruction as a two-way exchange of information even if the mode of delivery is digital. In this model of learning, the purpose of instruction is two-fold: the teacher has a clear idea of what concepts she wants to encourage students to develop and what skills she wants them to master, and the teacher uses instruction to collect real-time information on how students are thinking. The teacher uses that information to build hypotheses about how the students are thinking and then needs to gather further information to confirm or change her hypothesis before deciding how to adjust her instruction. This means that new tasks need to be given on the spur of the moment and the flow and plan of the lesson constantly changes as the teacher adjusts her models of her students.



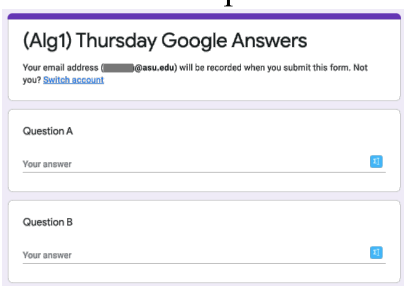
In the rest of this paper, I will discuss an example where I adapted live digital instruction to make it possible to attend to my students' thinking and adjust my instruction accordingly. These excerpts occurred in a private gifted school for middle and high school students using a hybrid model with an AB schedule where on "A" days half the students (the A cohort) can choose to come to school in person or log onto Zoom from home and "B" students must log onto Zoom from home, and vice versa on "B" days. Masks are strictly enforced on all students and staff, students sit 6 feet apart, desks and chairs are wiped down with bleach after each class, and the remote students can see the classroom via an Owl360™ microphone and camera that is supposed to (but does not always) follow the main speaker around the room. Each student has a laptop, and the remote students' faces plus any shared screens are displayed on a large TV for the in-person students.

In an Algebra 1 class with students from 7th to 9th grade, my co-teacher and I began the year with a review of arithmetic and other pre-algebra ideas. We wanted to make sure that the students understood how measurements of new quantities are constructed from known quantities (Thompson 1993), so I introduced a technique I created for my pre-service teacher classes called "structured expressions", inspired by my earlier work with Algebra students, the Pathways (Carlson et al. 2010) and DIRACC (Thompson & Ashbrook 2019) projects, and Alison Mirin. The students are told that they must give a numerical expression that calculates the answer to the question, *but they are only allowed to use the values given in the problem* plus any operation and grouping symbols they think are appropriate; they must also be ready to explain the meaning of any subexpression. There are three reasons to ask students to work with structured expressions: (a) they need to move from thinking of an operation as an *instruction to do*, to a *creation of an expression* that already represents a new value (Tall 1999), (b) it prepares them to think about expressions longer than one number when they start algebra, and (c) it creates the opportunity to ask them what the quantitative meaning is of each new expression created by each subsequent operation. Below is an example of a problem, a possible structured expression answer, and the precise quantitative meaning of each subexpression that we wanted students to be able to identify.



As you can see, becoming familiar with structured expressions prepares students to answer tasks like "What will her profit be if she makes *x* enchiladas?" or "Write an equation to describe the relationship between the number of enchiladas she makes and her possible maximum profit." with very little difficulty. Students will have already conceptualized the idea that an expression can represent a value even before they undertake the action of evaluating it (or, in the case of an algebraic expression, if evaluating is not possible).

It is difficult to predict how students will respond to any new idea. Each group of students will progress at different speeds, and so traditional online homework that sets a series of increasingly challenging problems does not allow the teacher to modify instruction using real-time information. To counter this, I created Google forms with 26 blank questions that had only places to put answers but no questions, as shown below. The students were trained to look to the teacher's shared screen on Zoom for the questions which would be labeled A or B or C etc., write their answers in the appropriate space on the Google form, then scroll down to the end and hit Submit. They could then click "edit my response" in preparation for the next question.



The idea of having a whole-class discussion where students suggest work to be placed on a single board is frequently used in both "traditional" and "reform" classrooms, but I have found that this approach allows the weakest students to hide behind their most outgoing classmates until a quiz or test. My pre-COVID expectation was to see an initial answer to *every* problem from *every* student before starting a whole-class discussion. This Google form replaced my previous analog solution of having students write on individual whiteboards and hold them up, since work held up to the laptop cameras (even on individual home whiteboards) was not legible.

By structuring my questioning and the student's responses in this way, we left room to dynamically change the flow of the lesson in response to student work. My co-teacher and I monitor the answers coming into the Google form in real time and analyze them to build hypotheses about student thinking on topics as varied as quantities, expressions, equivalence, changes, rate of change, order of operations, and the distributive and commutative property, among others. I then either move to my next prepared question, skip ahead, or spontaneously create another task to fit the needs I perceive in my classroom, and I can quickly re-label my questions accordingly. I end up with a spreadsheet of every student's first response to every task, but I am not bound by the pacing or questions that I thought would be appropriate when planning the lesson before class began. As I continue to learn and grow as a teacher, the speed at which I can form hypotheses and spontaneously create new questions grows, as well as the quality of said questions.

It is important to note that I do not only spontaneously create questions to address gaps that I see. I also create questions to test whether my assumptions are correct. For example, we recently had an exchange where I started to suspect that an infinitely long decimal number was not "a single number" to the students the way a terminating decimal was. I created a much simpler problem to try and isolate this phenomenon, and two students told us that "you cannot multiply $0.\overline{333}$ by 5 until you rewrite the decimal as $\frac{1}{3}$". The task did not clear up their misconception, but it strengthened my hypothesis that some students were still anticipating the act of multiplying in order to make sense of an expression (you cannot ever start long multiplication of $0.\overline{333}$ and 5 because you have to keep writing "3' forever). It also contradicted my earlier unspoken assumption that creating structured expressions with integers and fractions was enough for the students! I am now working on what kinds of tasks and discussions will help students to see an infinitely long decimal value as a single value that can be operated on. I hypothesize that the common American language of a decimal number "going on forever" implies some kind of changing value to a student, and now I must invent tasks which will illuminate their thinking on this subject to me.

This strategy of collecting answers and adjusting instruction on the fly in a hybrid classroom is certainly not perfected. To see the students' faces, my shared Zoom screen, Google responses, and to fluidly create new questions requires juggling a lot of technology –I am currently working with two laptops and one iPad with Apple Pencil all connected together via USB cables, Zoom, and a screen mirroring app. Google also does not let the students submit drawings so I have to sometimes collect images where the students draw or graph, take a picture with their cameraphone, and email it. However, my experiences show that it is possible to try and attend to student thinking even in the difficulties of COVID-era digital learning.

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