Instant Relevance

Using Today's Experiences to
Teach Tomorrow's Lessons

Denis Sheeran

Instant Relevance

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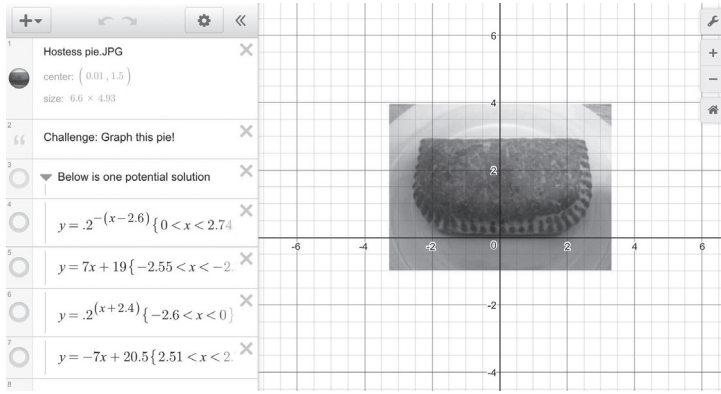
Why My Students Care About My Lunch

I like to eat. For me, eating regularly battles for the top spot on the list of things needed to survive—sometimes losing out to sleep and occasionally to a fresh cup of coffee. But as you most likely know, not all foods are created equal, and some could even be considered abominations of nature. So one day, when I was sitting in the kitchen with my wife—wondering why our kids were nowhere to be found and what it was going to cost us once we found them—out of the blue, she said, "Hey, do you remember those Hostess apple pies? The ones you get at gas stations? I always wanted those as a kid." I instantly pictured the headline: "Man Divorces Wife Over Unhealthy Pie Preference." After realizing divorce probably wasn't the best option, something else came to mind, and I replied, "That 'food' is not worth eating—but it *is* worth graphing!"

So I took my nerdery to the best place to graph things you wouldn't expect to graph: the online calculator at Desmos.com.

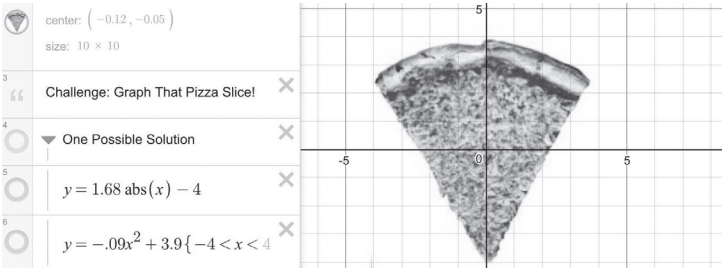
Here's the result:



Abomination of Nature

Here's where Instant Relevance kicked in. I've done things like this in the past—Tweeting graphs of food or trees or other graphable things to my math friends for their approval and sometimes just taking pleasure in living up to my own graphical expectations for myself. This time, though, I took the graphing challenge to my students. I told them about my wife and her therapy-inducing desire for that aforementioned food product and then sent them the link to the pie graph (pun intended) with two challenges: First, graph the pie. Second, graph the pie using the fewest number of functions possible.

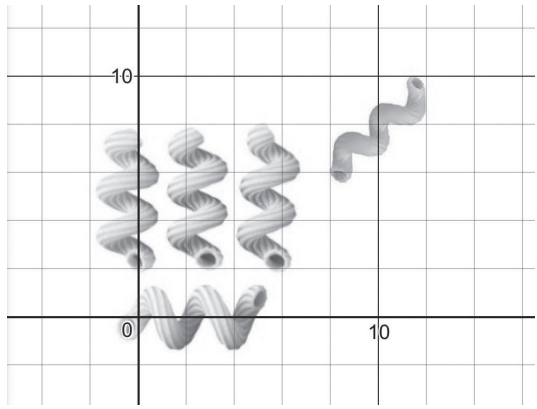
They loved it. (The graphing, not the pie—no one likes those pies. That's why they have indefinite expiration dates.) The best part, though, was the next day when my students came to class asking, "What food are we graphing today?" I hadn't expected this, so I ran to my office and grabbed the slice of leftover pizza I'd brought for my lunch. I took a picture of it, uploaded the photo to Desmos.com, and set them to task. I ate my lunch while they came up with this:



Graph 2: Lunch

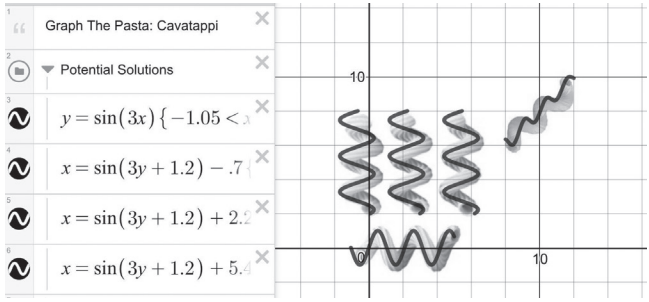
The rest of the school year the question, "Mr. Sheeran, what do you have for lunch?" was much more than small talk—it meant a connection to learning. My students knew I'd bring food that I didn't even like, just so they could graph it. We didn't do this every day. We did have other topics to talk about that graphing wasn't a part of, but I secretly hoped they were starting to see the things around them the way I did—as opportunities for graphing, investigating, and learning.

Turns out, they were. I started receiving e-mails with links to graphed hamburgers, tomatoes, candy, vegetables, and more. Then, one day, I sat down to dinner and there it was, staring at me. In nine to twelve minutes, over medium-high heat, my wife had prepared the most difficult math graphing task I've ever encountered: cavatappi pasta.



Cavatappi Pasta 1

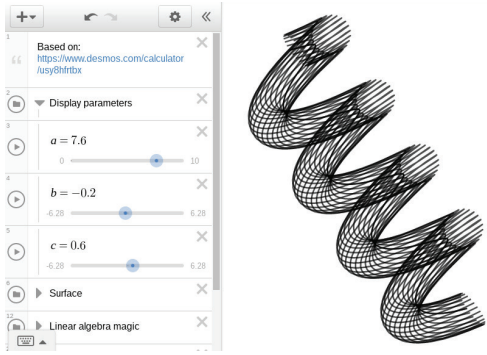
It was actually pretty easy to use trigonometry to hit the curves. (See, trig *can* be useful!)



Cavatappi Pasta 2

Then I asked my students to take on the bigger challenge: to graph the tube itself. *How do you graph a tube?* It became such a huge task that it took the rest of the year for them to realize something very difficult:

they just couldn't do it. But instead of giving up, we asked Desmos's founder and CEO, Eli Luberoff, and his team if they could help. One of the most important things a student can learn in their school career is that they are not intended or expected to be masters of everything, and *sometimes* it's best to ask someone who knows more than you do. This was one of those moments, and, amazingly, Eli and the Desmos team came through with this amazing creation:



Cavatappi Pasta Awesome

A simple, easy-to-make dinner became a challenge too big for my students to accomplish alone then transformed into one of the most important lessons they'll ever learn: accept challenges, persist, ask for help, and learn.

Thinking Questions

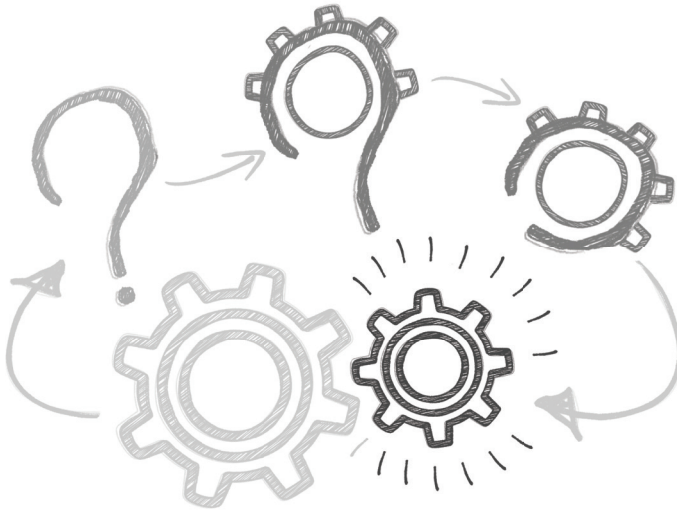
1. When a small idea grows too big to handle, do you abandon it or do you find help?

2. Do you have any ideas that you've abandoned that you'd like to revive?

3. What everyday needs, like eating, can you use to connect your lessons to your students?

HACKING MATHEMATICS

10 Problems That Need Solving



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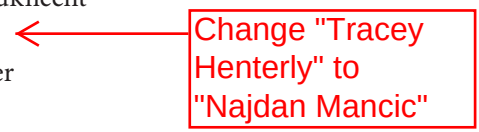


SOLVE THE CALCULATOR CONUNDRUM

Choosing an instrument for all students: desmos

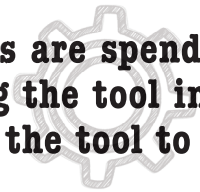
Man is a tool-using animal. Nowhere do you find him without tools; without tools he is nothing, with tools he is all.

– Thomas Carlyle, Scottish Philosopher

THE PROBLEM: STUDENTS DON'T KNOW HOW OR WHEN TO USE A CALCULATOR

In a strange turn of events, one of the staple comments that I was told by my math teachers and that I told my own students when teaching them at the beginning of my career has been completely reversed and is absolutely no longer true. What was this statement that I, and likely some of you, told our students? This: "You've got to know how to do this because you won't have a calculator

with you wherever you go after you graduate." As life and advances in cellular telephone technology would have it, they do have a calculator with them everywhere they go. It probably even talks to them, so they don't even need to read an answer. If they've got the right apps installed, it may do math for them before they even ask it to.



Teachers are spending time teaching the tool instead of using the tool to teach.

The problems now are: When is it OK to use a calculator? What type do I need? And how should I use it? The answers to these questions vary, depending on the grade level you teach, the state or country in which you live, and your goals for the lesson. In many places, like in New Jersey where I live, students take the PARCC standardized assessment in math. Your state might offer the Smarter Balanced Assessment or its own standardized assessment. Each of those tests has different calculator requirements based on grade level and course. For example, on the PARCC test for grade six, students can use a four-function calculator. They can use a scientific calculator on the eighth-grade test and a graphing calculator on Algebra 1 and higher. On the third- through eleventh-grade English assessments, surprisingly enough, they are not allowed to use a calculator at all.

What I've found troubling is that many teachers do not include the calculator as an effective tool in class, but

merely take it out to show the students how to turn it on, push its buttons in the right order and find important symbols or menus so that the students will know what to do with it on the test. The problem is that even though they may know what to do with it, they often don't know when it's appropriate to use it at all. Teachers are spending time teaching the tool instead of using the tool to teach. Let's look at the calculator conundrum together.

THE HACK: SOLVE THE CALCULATOR CONUNDRUM WITH DESMOS

You may still be struggling with knowing when to suggest a calculator in class. Here's a tool analogy for you. Have you ever pounded a nail into a piece of wood with your fist? Of course you haven't. That's what hammers are for. So if you know that you need to pound a nail into a piece of wood, and you know why you need to pound the nail into the piece of wood, and you want to make sure that the nail actually does get into the piece of wood, then you reach for a hammer. Are you teaching your students how to solve quadratic equations or simplify radicals or add fractions? Are they losing points on your tests, not because they can't solve quadratic equations or simplify radicals or add fractions, but because they made a mistake on a previously taught arithmetic skill? Then they should be using a calculator. If, at any time, the learning of a new concept is impeded by our own need to make sure our students can do it all in their heads, then we are the ones making the mistake.

Which tool do you choose? If you looked into my toolbox in my garage you'd see drill bits, screwdriver bits, hex wrench bits, socket wrench bits and other assorted bits. That's because I have one favorite tool in my toolbox: my power drill/driver. On its own, it doesn't do anything but spin. But when the right bit is installed, it can drill holes of all sizes, insert or remove screws of any type into any space, loosen or tighten even the most stubborn of nuts and bolts, and even power saw pumpkins into jack-o-lanterns (I speak from experience). In the hands of someone who knows what it's for, how to modify it, or even how to hack it for a new purpose, the tool becomes more than just a spinning device. It makes hard jobs easy, impossible jobs possible, and is right there when I'm not sure what to do next. It becomes a necessity. Do you want a tool that can do all of that in your classroom? It is Desmos.com.

Desmos is a four-function calculator, a scientific calculator, and a graphing calculator all in one. But it's much, much more than that. In fact, it's so much more than that that the Smarter Balanced Assessment has abandoned its ties with Texas Instruments and signed on Desmos as its embedded calculator for the online assessment. The real gem of Desmos is not that it's a three-in-one calculator solution, but that it includes an Activity Builder that turns the calculator into a tool for investigation, learning, teaching, student management, and deep mathematical understanding.

WHAT YOU CAN DO TOMORROW

Let's stop taking pride in our ability to draw a really great sine curve or to find a common denominator faster than our students can find it. Instead, let's take pride in our ability to create an activity that teaches our students that the tools are available for their use, but they've got to know when and how to use them. Here's how you can get started tomorrow so you will be prepared to introduce it to your students.

- **Go to desmos.com and start graphing.** Visit the website. Once there, check out the four-function and scientific calculators on the bottom of the main page. Then click the Start Graphing icon and play with the grapher a bit. You'll soon see how much more powerful it is than student handheld calculators.
- **Go to teacher.desmos.com.** This is the hub of the Desmos Activity Builder. The educators and developers at Desmos have created excellent activities for you to investigate as a teacher, try as a student, and copy for yourself so you can modify them to meet your students' needs. Take a look at what's already here.
- **Go to learn.desmos.com.** Ready to dive deeper into how to make cool things like

moveable points, animated graph features, and your own activities? Head here to access instructions and tutorials.

- **Visit the activity bank.** Remember the MTBoS from Hack 3? Well they've put together a Desmos activity bank at mtbos.org/desmosbank. Search there for your grade level and content area and see what's out there already.

A BLUEPRINT FOR FULL IMPLEMENTATION

Step 1: Start by test-driving the tool yourself.

By investigating the calculators, grapher, and various styles of activities available through Desmos, you'll have a strong sense of what you can do to Desmos-ify your classroom. You may want to introduce Desmos to your classroom as a display tool and show students a concept visually. Take time to get to know the different functions of Desmos. Once you can effectively use the grapher, making activities will be an easy-to-learn experience. If you want to see great examples of what other teachers and students are doing with Desmos, go back to the main site page and scroll down. You'll see featured art made with the grapher and also staff picks of their most interesting mathematics examples created by users. Not only can you share these in your class,

but you can learn how to make them yourself by checking out the math that was done to create them.

Step 2: Swap out an upcoming lesson for a Desmos activity.

You'd be surprised how much your students can learn without the information being told to them directly. Desmos activities encourage investigation and conversation and can often reveal that your students know much more about a topic than you previously thought they knew. If you've got a lesson on quadratic graphing coming up, teach the Match My Parabola activity instead. If you're teaching place value, teach the Place Value Polygraph, which is a game like the one you may have played as a kid, Guess Who. If you're teaching about linear functions, you can likely swap out the entire chapter and replace it with the Linear Bundle of activities that Desmos has prepared. Keep in mind that the library of activities on the Desmos page is not exhaustive, but is instead a collection of activities created by the Desmos team and by users. If you want more, visit the MTBoS bank or just Google what you want with the phrase "Desmos activity." You'll find what other teachers are making. Go ahead, try searching "systems of linear equations desmos activity" and see what you get. You will be surprised how easy it is to find what you need and swap out a lesson.

Step 3: Request an observation and feedback.

If there's one thing that will build support for the Desmos calculator and activity builder in your school, it's just giving

people the chance to see it. The phrase I hear most when teachers and administrators see it in action for the first time is, "I wish I'd been able to learn math this way." That's powerful. Once you're comfortable leading an activity in class, call in peers or administration for feedback on your new method of teaching a topic. Not only will this show transparency on your part about sharing a new tool, but will likely garner more support for moving ahead with Desmos among other teachers as well.

Step 4: There's a time and a place for the handhelds too.

Most smartphones have the capability to be a calculator. In fact, in most cases, you can just ask your phone a math question verbally and it will answer it for you. My Android phone automatically starts reading me the answer out loud when I ask it a question. But, it depends on the question I ask. Here's a conversation I had with my phone today:

> *"OK Google. What was my average rate of speed if I drove 472 miles in six and a half hours?"*
> *"I do not recall"*
> *"OK Google. What is 472 divided by six and a half?"*
> *"472 divided by six and a half is approximately 72.6153846154"*

The one message we've told our students about calculators that is still true is that they will only do what you tell them to do. In this case, the smartphone calculator didn't

recognize the context of my first question as a calculation question, so instead it searched for a fact that it might have known. It never found that fact. This is often how our students act when confronted with a math question. Instead of looking deeply at the question, they search for a fact or a procedure to apply—often not finding it, or applying the incorrect one. It's our job to make sure they can tell what a question is asking and determine what needs to be done to answer that question.

If arithmetic calculation or graphing are necessary to solve the problem, then it's time for the tool to spring into action. Giving them a calculator at this point in the problem will give them numbers or visuals they can use while the problem is still fresh in their minds. If they have to take time to pull out a sheet of scratch paper and do a large multiplication problem or hand graph points to analyze, they've often lost the flow of their thoughts and come back with a confused "where was I" feeling.

OVERCOMING PUSHBACK

There will be a handful of people who still think that anything that can be done with a calculator should be taught to mastery before ever touching the device. They usually also think that knowing trig tables will help in case there's a nuclear apocalypse. Here's how to assuage their fears.

The kids aren't really learning the math if they're using a calculator. My daughter, who's in eighth grade, was simplifying rational expressions which contained negative

exponents and constants on a test. In the problem, she changed every negative exponent to a positive exponent correctly and also simplified the variables afterward correctly. At the start of the problem, she made the mistake of reducing 8/12 to ¾ instead of ⅔. She lost two out of six points on the question for this. You tell me, does she deserve a D on this question because of an arithmetic mistake that could have been calculated with a machine? I don't think so. But now she thinks that she doesn't know how to simplify rational expressions with negative exponents. Luckily enough for her she has a math teacher at home to tell her the opposite. Not every kid has that. For the teacher with this pushback problem, I ask: Are you really assessing the math they're learning or just their ability to do arithmetic again?

They can't use Desmos on standardized tests. This is rapidly changing. In fact, the Smarter Balanced Assessment, which is offered in fifteen states (PARCC is only in nine), signed a partnership with Desmos, which is now the embedded calculator on the assessment for all test takers in grades six to twelve. Desmos even partnered with the assessment to offer an accessible calculator for blind and visually impaired students. Add to this the fact that the calculator is free for teachers and students, and according to the founder, Eli Luberoff, always will be—and you've got a relative likelihood that Desmos will overtake Texas Instruments on the testing market soon.

If Desmos activities are so good, then what's the point of having me there? Show these teachers the teacher.

desmos.com teacher dashboard of an activity. There they can see that they're able to manage the pacing of student work, see every student's response to every question, see every graph each student made along the way, overlay them for investigation, pause the activity and ask questions or point out interesting developments, and much more. Desmos activities put the teacher into the place of the highest value, as analyzers of their students, individually and as a group, and as expert decision-makers on how to proceed with each student's learning.

THE HACK IN ACTION

In my own earlier classroom, I applied what I called the TicTac method. It stands for Teach, Investigate, Calculate… Talk, Act, Check. I would Teach a topic briefly then ask students to continue to Investigate it through materials I prepared (I wish I'd had Desmos during those years). Then they'd need to Calculate to have information to use, so at this point it was calculators out. Why would I stop the flow of thinking to have them hand calculate when what I needed them to do was obtain numbers to use in the next step, Talk? After they'd gotten their calculations, they'd talk about what they thought they meant in the scope of the problem, maybe even revise their work based on the conversation, and then Act on their conversation to continue solving the problem to the end.

The last step, Check, would also include the calculator. Why would I have them plug their answers back into a

problem and hand calculate to see if they are correct, when they can find that out faster by using a calculator—and if it was incorrect, go back and make a strategy or procedure change. The TicTac method put the calculator in its place as a tool for helping the learning process. I never told them to take out their calculators so they could get used to where the buttons and features were for the standardized test coming up. That doesn't really inspire an understanding of when to use the tool.

I recently modeled a sixth-grade Desmos lesson for a middle school where I was doing professional development in New Jersey. The lesson was on comparing rational numbers and fractions, so I prepared an activity for students. These eleven-year-olds easily logged into Desmos, signed in with their Google accounts (a necessary step if they ever want to go back and finish an activity later), and began the activity. On one slide of the activity, they were dragging and dropping points on a number line to estimate where they thought might be. I noticed from the teacher dashboard that there were two distinct areas where students were placing the point, so I clicked the pause button on the activity. When I did this, every student's screen went gray and showed, "Activity paused."

With no words on my part at all, twenty-four sets of eyes looked right up at me as if to say, "Why did you stop us?" I now had their attention and was able to ask questions about their estimates, the two areas of prominence,

and what they expected to happen in the next estimate. I released the pause and let them go back to the activity.

I never would have been able to see all twenty-four students' work like this if the activity was on paper. After walking around, I might have seen a trend, but Desmos allowed it to appear instantly and serve as an instructional tool while it was still happening. This is just one example of how a power calculator tool with multiple features can change the nature of your instruction for the better. You've got to know which bit to put into the drill, so start looking for it.

There is significant value in students knowing math facts and how to calculate in their heads. Our brains are the fastest calculators in the world. How else do you think we can shoot a basketball into a hoop from thirty feet away? A math teacher takes forty-five minutes to calculate this with students; a basketball player solves the problem before knowing it's a problem. But, in the system in which our students are schooled, they learn new concepts every day and sometimes before they're ready. If we find that our students' grades, or more important, their actual conceptual understanding of a new topic, are being held back by a struggle to get the basic math component of a problem correct, then give them the hammer and watch them build. And when you're ready, make Desmos a part of your class every day.