Introduction with Mary Jean

>> I worry today in Ontario's classrooms with this debate that I'm hearing. We've got to have them do all the fundamental drill and stuff and fill in the worksheets. No, no, no we're afraid people have been doing too much of that so we're going to do all this high end problem solving stuff. But somehow in the middle of that we may have forgotten that the best teaching and learning in any subject area happens when a teacher knows their students and their abilities deeply, and knows the full breadth and themes of the curriculum, and is able to engage kids in learning activities using a diverse range of teaching strategies that will in fact have each child deeply engaged in learning the subject. That's the description in my mind of what a comprehensive mathematics programming classroom's about. It takes a lot of skill and it takes probably a deeper understanding of mathematics and the way in which kids learn mathematics, then we, for the most part across our province, actually own as individual educators. I know there's a whole lot I have to learn about it so I suspect I'm not alone in this room or this province. We need those higher level math skills not only to ensure students have the requisite job skills they need but we do it to ensure that we're developing the strongest minds possible to solve the challenges of tomorrow. Virtually any one of our technologies we use that are so helpful to us began in mathematics theory. We also want young people to be able to use the tools of math including arithmetic with skill and precision, I call it automaticity, it's what we used to call a student being able to read competently and quickly, and the higher problem solving thinking that they need and the wonder of mathematics and it's way in the world. The OECD defines math skills as an individual's capacity to formulate, employ and interpret mathematics in a variety of context. This includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. Mathematical literacy also helps individuals recognize the role that mathematics plays in the world and make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens, and I think that's a pretty good description in my book about what mathematics is about. We also know that good things tend to happen when there's collaboration so it's our hope that amongst your peers you will think out loud, discuss what is and more importantly what could be when it comes to mathematics learning in our boards and in our classrooms.

Attitudes about Mathematics

>> George Hart: As someone who loves math, I'm kind of saddened that so many people don't love this thing which I'm so passionate about. So to a professional mathematician, math is this wonderful, creative subject. And unfortunately, in popular culture, it's not always seen that way. And some people end up hating arithmetic or algebra because in school they didn't understand it or the way it was taught. And the sad thing is that they don't even know what math is yet; they're only seeing the slightest bit of what math is. And so part of my mission is to explain to people about the larger picture -- how math is so much more than what they see in school.

>> I've always liked math. And it's been always -- always been fun. But now it's more like a thinking problem, less of, like, a writing down "This equals that" because that's really boring. Like, that's not really math. Math is more of, like, solving problems. And the basics is usually, like, adding; and subtracting; and doing fractions. But then there's way more to it than just that. And before, we used to only do that. You know when you get older you have to buy, like, more important stuff? So you would have to know "What is a better deal?" Like what we're doing now, "What is a better deal?" Like, pretend we're buying a house, and this is how many square metres for how much money. And then you compare three houses and see which is the least expensive and which is the best for you.

>> It's always fun to show up to math class every day.

>> We just really like all the different questions. You put stuff on kid blog and everything. We all sometimes work together, sometimes individually. It's all really -- we have a lot of fun just really exploring math.

>> It's a big variety [inaudible]. It doesn't feel boring to me. It feels like I can add creativity to the subject.

>> Math is one of the most important things. You know, you have taxes; you go to a grocery store. You know, you need to know math, like, what can fit in your budget and make sure you don't go over what you can actually afford.

>> I never forgot one thing that Mr. Oldridge told us in grade six. He told us that when you're going to the cashier, sometimes when he's there paying, he tries to calculate prior the cashier being finished how much he's going to end up paying.

>> When you talk to most of the classmates, they all like math. Like, it's one of their favourite classes, if not their favourite.

>> And it could be fun if you know what you're doing.

[Inaudible]

>> Yeah, only if you know what you're doing. Because if you don't know what you're doing, you'll be lost and you think it's like, "Oh, I can never do this." But at the end of the day it's actually pretty fun.

>> In a way, it's another language. Because, like, a lot of people -- it's the way, like, most people connect. Like, music except for, like, a lot of people know math. And math just brings us together in a way. Like, it's confusing. But it works.

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Growth Mindsets in Mathematics

>>Jo Boaler: So a top researcher at Stanford, Carol Dweck, has shown through decades of research that people have one of two mindsets: If you have a growth mindset, you believe that you get smarter the more work you do; if you have a fixed mindset, you believe that you're smart or you're not and there's not a lot you can do to change that. So it turns out these different mindsets have huge implications for the learning of math and they change kids achievement in math pretty drastically. So we know that the lowest achievers, both in the US and in the world -- we're just getting new data from PISA on this -- we know that the lowest achievers are the kids with the fixed mindset massively by massive differences. They achieve differently to kids who have a growth mindset. And that's because growth mindset behaviours are really helpful. So kids with a growth mindset, if they fail because they don't think it means they're not smart, they'll keep going and learn from that. They're more persistent. They're more able to work through hard things. So we really need kids to have a growth mindset. So there are interventions. Fortunately, people's mindsets can change. There are online interventions sort of on general mindset that kids go through. And the data shows that they can be achieving at one level, they do a mindset intervention, and then they're going on a whole different trajectory. So I really believe that kids need mindset interventions in math. Like, math is the subject with the most fixed mindset thinking.

>> Matthew Oldridge: Number one, believing that they can all do math from the very beginning that they step in here. And that's absolutely number one.

>> I for one aren't the world's greatest at math, but he gives me a chance in class to show that I can do the math and I understand the math.

>> For me personally, I, like, hated math throughout, like, grade one to five. And then we came here and then we did so many projects. And it was a lot of fun, you know, working your friends and everything. It's more fun. And I don't think you can be born with, like, perfect math skills. Like, no one's born, like, a mathematician. Like, you have to work. It's a skill; you have to build it up. So, like, if you're scared of doing it, you have to, like, kind of go out and try and, like, figure it out what you're good at.

>> It takes a lot of determination to become good at something because you have to understand that it takes practice to become, like, something a bit -- like, for math you're not born with it. I don't believe you're born with anything. I think you have to work towards it. And if you really want it, then you'll work hard enough for it and you'll get it. But if you don't work for it, then you're just

dreaming of it, then it's not really realistic and it's not going to happen.

>> Well, I had friends in the past who have had problems with math. But I find if they were in our class and they had all this, like, nice help and stuff, I think they would love math.

>> I used to think I was really bad at math but then when Mr. O. started bringing these different kinds of ways we could do math, I think I got better and, like, I learned better.

>> Jo Boaler: We used to think from research that being good at math was all about this knowledge you developed. We now know that just as importantly -- possibly more importantly -- are the beliefs you hold about yourself, and math, and learning, and the messages you receive. So one of the studies that really shocked me that showed this more than anything for me was a really big experiment they did with large numbers of high school kids who had to -- they wrote an English essay. And then they all got diagnostic kind of challenging comments, diagnostic comments. And half of them got one sentence added at the end and the other half didn't. And the half that got the sentence added did -- and that was only thing different in their whole year -- did significantly better in exams and tests a year later. From one sentence. I mean, it was pretty shocking. But the one sentence was -- and this was put at the end of the teacher's feedback -- "I'm giving you this feedback because I believe in you." And the kids who got that, I mean, it's just incredible. Nothing else changed. The teacher didn't know who got that sentence. So I share that with teachers not so that they go around writing that but just to show the power partly of teachers' words but also the importance of kids knowing that their teacher believes in them. Turns out, kids are processing this all the time, every day in class: "Does my teacher believe in me? Are they telling me this because they don't think I can do it? Are they giving me this work because they don't think I can do it?" So these ideas and messages kids pick up are just as important or more important than what they learn cognitively.

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Student and Teacher Efficacy

>> Cathy Bruce: Student efficacy is the student's belief that he or she has the ability to learn. And this is a really key part of learning in mathematics because students with high efficacy with persist longer with difficult problems, and it is correlated to student achievement as well. One of the key things to remember about efficacy is trying to build mastery experiences for students. So a mastery experience is where the student tries something that's a little bit more challenging than they might expect within their zone of proximal development but pretty challenging, and they have success. Then they say, "Oh, that was amazing. I really know what I'm doing. I really understand that. I feel so good. I can learn. I can learn mathematics."

>> When there's something more challenging, it's always, like, fun when you figure out, like, the answer -- especially when you've been working on it for a really long time. So like, let's say I have an algebra problem or something like that, and I'm just staring at it for five minutes and then I finally figure it out, it's, like, it gives you a feeling of accomplishment.

>> I really like math because it's a challenge every time a teacher throws a problem at you. And I feel like every time I get, like, a math problem, I want to, like, solve it and be, like, the first one to know. So I feel like math is just, like, a challenge in, like, everyday life and it really relates. So I personally think that math is fun to do.

>> [Inaudible] but, like, being with, like, these girls and everything like that. Like, when I, like, cooperate with them, they will always, like, show me how to do something or something like that. And then we, like, learn more and more.

>> You feel pretty confident?

>> Yeah.

>> Once you figure out something, it's just, like, a great accomplishment. Yeah. It's like you did something right. Like, when we did integers, I used to suck at them. But then, like, now, yeah, like, she would help me through it all the time. And then she'd explain to me, like, how to do this, how do that. And now I understand it all, like, and I got good on it. So I just need someone by my side to help me. That's it. It feels good. It really, like, clicks.

>> My attitude towards mathematics is a positive attitude. Like, I'm always ready to jump into class, get started on whatever activity Mr. O either pulled up on the screen or, you know, questions we've been

given on a worksheet in class. I feel confident. I feel like the support I need is there. So if I ever need some help, I could obviously go ahead and ask Mr. O. He's very helpful.

>> Cathy Bruce: Teacher efficacy is the teacher's belief that he or she has the ability to help children learn. And lo and behold, if a teacher has high efficacy, it has an impact on student achievement. So teacher efficacy is directly connected to student learning and student achievement. It's a better predictor of student achievement than socioeconomic status. So when the teacher believes, "Hey, I can help a kid learn," that translates to persisting in the classroom with students and letting students kind of muddle for a little bit, letting the learning take place, rather than doing a lot of telling. So all of those things start to come into play, that when the teacher has high efficacy, they're using more effective strategies in math in the classroom. That then has an impact on students and student efficacies.

>> When he gives us work and he sees something is wrong, he doesn't tell us. He's, like, "Okay, guys. Just look back at this, look back at this." But he doesn't say, "This is wrong." So we have to figure it out on our own. And then, yeah.

>> So I feel like he's just trying to help everyone who doesn't understand it and give them little hints and clues to figure out the problem. He tells me to think logically sometimes and think, like, not just sometimes think just logically or think mathematically. And I feel like it's really working to help me go forward.

>> If you have any troubles, he helps you, but it's more vague. So you have, like, a sense of independence. So it really prepares us for high school.

>> I do see math in my future. I might, you know, do master's degree in math or something like that in university. I'm taking academic courses for math in high school because Mr. Oldridge really made me think a different perspective in math than just encourage me to, you know, do it in the future.

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Engaging Students in the Mathematics

>> Classrooms that I visit, classrooms that I have written case studies about, one of the common threads is the degree to which students are engaged. Typically these are active classrooms where students aren't sitting still. These are noisy classrooms. The noise is on task noise. When the teacher asked a question of the students in that class, no hands went up. It was a simple no hands rule which the kids adhered to because it made sense to them. A question of the class is a cue for the students to talk among yourselves; problem solve, argue, and they were arguing. That's student engagement; where students have forgotten about...there was no question of what's my mark? They're fixated on which is a naturally engaging task. Kids are from whatever age innately curious. We as human beings are learning machines. We must make sure that in all of our programs, in our mathematics programs especially, we don't stifle but we encourage and we fuel the curiosity and inquisitiveness which is fundamental to learning for all kids.

>> Well when you walk in the classroom, you don't know what you're going to see. Maybe you can see...there's something new every day that you incorporate into the math.

>> Well Mr. O just really connected with math a lot. Like he instead of just throwing any like math problem any teacher does, he really like goes out of the box and finds something we'll relate it to like something we know like Twitter. Like he did a problem on Justin Bieber which everyone really loved. And everyday life like he did a project with baking. He just throws something new every time we come to class. Like the movie theatre one and the Justin Bieber problem, Twitter problem; I just feel like it's really exciting to be in his class because he doesn't throw like the same type of problem every time. It's always something different that every student looks forward to do.

>> Like I'm learning a lot in this class. Before I thought math was kind of just like just another subject and something I have to do. But now I feel like I want to go to math and I'm excited to go.

>> When you can apply like the math that you're learning in class into real life situations more like this for example. So like next time I go to a movie theatre I'm going to...you know you can decide whether or not you're paying you now the right amount for something and other situations like that.

>> I think I love that like in this class we don't work out of a textbook; we do work that will relate us to the world so it kind of helps and we're more interested. Not only just about learning math, it's about like applying so obviously we're going to do like some work where we sit and we do worksheets for a period, but then we do like

projects, groupwork and get to connect math to the world so that kind of helps us interact and figure it out.
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Creating a Collaborative Culture

>> Well math shouldn't be a secret right? And if everyone's just sitting, working quietly out of a textbook I'm not hearing their thinking because nobody's saying anything. Or the thinking's not as open to them all the time depending on the questions they're working on. But if they're talking to each other and we're building on top of that, that's where the real meaning-making happens.
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[Inaudible background conversations]
^M00:00:27
What's exciting is seeing all the different ways it happens and seeing the quality of the collaboration, how everyone can just talk math to each other and just jump right in. So once everyone's used to collaborating and talking math, our job gets a lot easier. Because as you saw everyone can jump right into working on the chart paper and solving the problem. Everyone in this room I've been working with for almost three years now so I've had a chance to build these routines of collaborating on math and seeing math as a really open problem-based and skills-based endeavour. That said, if you just have one year with the same kids and you start this way, you start by solving problems together and you start by asking interesting questions, then it will happen. It doesn't happen overnight but it will happen. Once you unlock the power of collaborating in math it always exists. You know they know how to talk math to each other. Some hurdles to overcome, making sure everyone's voice is heard and starting to build the trust and making it so everyone knows what's expected of them, you know, whether you have to work on your norms of collaboration or whether you have to have some protocols or not, it just becomes what's used to and expected. Sometimes you find that they're just not used to talking to each other in math so a lot of work to be done in how we talk to each other, you know? It's not just staying on task, it's having specific mathematical language to use. But what I do find is regardless of if you've known them for a couple years or not, if you start the year with some kind of big problem and allow them to collaborate you can then build the culture. Yeah I don't recall what my first problem in September was, but that's the very first class, not as Paul was saying, a week of r- week and a half of review as we sometimes see, but jumping right in, building the classroom culture from the beginning. So some that are good are the type of like Fermi problems for example where it's so open-ended because they have to choose some kind of estimation tool which becomes the frame of reference for exploring it. So I've started with that sort of thing in the past. Because there you can talk about different types of strategies, the types of thinking that happens, it could really open the conversation. If you just start right from the very beginning they will know that they're supposed to talk to each other. As far as assessment goes, a lot of the correcting happens to each other, and a lot of the moving each other along happens together. And so what I find is whether I'm standing right beside giving a prompt or not, it's happening.

>> Also with all the guys that I work with, they help me improve and I, they know certain things in math that I don't, and I know certain things they don't know in math. And it's just different ways they can teach me and I can teach them.
>> And I mean never talk more than your students. That's my number one principle.
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Developing and Taking an Inquiry Stance

>> Dan Meyer: Inquiry results in some powerful classroom cultural changes. I've had people say -- and I think this is true -- that you just can't start doing this in May and expect students will just, like, make the transition. For me, it started with really being interested in the contents of students' heads beyond a grade or a mark at the end of the year. So I wanted to know, like, "So how are you seeing this problem? What are you thinking about this?" in a sincere way. It took sincerity, I think, to start changing how my students saw me see them. Like, "Oh, my teacher thinks that I have, like, valuable stuff in my head. Okay, I'll offer more of that." That was a huge step for me. And, you know, asking students, like, "What questions do you have about this?" in a way that is sincere and doesn't seem as though I'm fishing for a particular question -- that's another big moment for me where I had to, you know, shed some of my desire to control the process and become sincerely interested in them. And from there, there's baby steps that I took. For instance, asking for intuition, asking for guesses was something I did to bring in learners who didn't have quite the strong handle on formal mathematics as other students did. It brought them into the fold and gave us something good to talk about. So these are all, like, a part the process of transforming the culture of a classroom. No one should be confused that inquiry is just, like, a set of teacher moves or a set of a teacher skills. It's this really profound -- for me, anyway -- profound cultural change in the classroom. With students who had been really successful at being given the formula, told how to use it, and then given problems to replicate that, they were frustrated at first. Like, they do not enjoy this transition away from a system they had been really successful with. But what it takes is the awareness that what they are doing is only a small fraction of what math is. Like, computation, memorization, manipulation of symbols. But that's a part of math, certainly, but only a part of math, not the whole thing. So I had to just, like, internally say to myself, "You know, this other stuff -- abstraction, applied problem solving, that sort of thing -- that's also a piece of mathematics" and just to consistently emphasize that.

>> Matthew Oldridge: Once you start to take an inquiry stance in math and you start to ask a lot of questions about the numbers that you see around you, "Why are the numbers such as they are? Why does this graph look like this? Why is this price like this?" and once you start to have those questions, that to me becomes the basis for your whole math program. Ideally, students would ask those questions and they can, again, once they're given the opportunity. So I think I would never sit here and say we're going to completely throw out our textbooks. I use them once in a while when we need to practice a concept usually. But instead of starting in the textbook, if we start from questioning and if we start from looking for math that's in our own lives, and that's interesting, and bring it into the classroom,

that's much more interest for kids.

>> If you just take math, I guess it can be kind of boring. But then if you compare it to, like, science and, like, modern-day activity that we're all, like, dealing with and, like, put that with the math, then it becomes really, really interesting.

>> At least you can explore.

>> Yeah.

>> The thing that I like about math is the experiments you get to do and the things you get to figure out.

>> Matthew Oldridge: Getting them comfortable asking questions in math, like this brainstorming here, it's knowing that they will wonder about math. Once they're allowed to see that it's not just books, strands, lessons given by a teacher expert, they will start to know that it's out there. So -- and they've asked some pretty amazing questions and they continue to do so. And once they start looking for math in the world, they don't stop. I think it's taking more of -- dare I say it -- an inquiry stance to math. It is, it's taking an inquiry stance to math because the questions spur other questions. And my question about "Why is the one cup size so disproportionate?" you know, spurred this problem, which is spurring their questions.

>> [Inaudible] he, like, prefers that we interact with it and figure it out, like, for ourselves. Because not everyone's, like, instead of going old school by, like, formulas, like, you have to kind of figure out which way works for you. So it kind of helps you, like, understand concepts and everything.

>> Laurie Letourneau: In terms of looking at the inquiry process starting with where the students are at, that there's a definite respect in the way that you engage with them in conversation and that you really try to develop an understanding of who they are and what they're interested in. And I would say that's probably where the whole idea of Minecraft came from because we certainly had a group of students that were interested in using it.

>> So basically, I think the math question just creates, like, a whole conversation based on the topic. Because I feel that questions normally, like, start a conversation. And instead of just saying, like, a statement, it doesn't really create a conversation. So that's why I [inaudible].

>> Matthew Oldridge: Every learning is better when we explore our own interests. So my innovation -- my big idea -- this year was just having everyone explore their own math. And it was very freeing because all of a sudden, we had math from all different walks of life,

or parts of the world, or different types of things like music, baseball, infinity. And it's more in keeping with what, you know, scientists or mathematicians do anyway: They ask questions and they don't just stop at one thing; it always sparks the next investigation or the next inquiry. It started us asking a whole lot of questions.

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The Three Part Lesson An Overview

>> Lucy West: So there's a whole movement these days in the US for the workshop model and what I think Canadians call the "three-part lesson plan." And I think that's a little misguided. And I think it's misguided because you're focused on a format, you're missing the essence. So for example, a three-part lesson could take two or three days to complete if it's really rich and interesting, and the conversations along the way might not happen exactly at the end. And how people confer with kids are really what it's all about when the kids are engaged in something.

>> Anna Presta: The other thing, too, is -- now, I noticed you're on Rotary -- but do you do the three-part lesson, and I know teachers have found that challenging sometimes to do the three-part lesson on Rotary. So I wonder, how do you manage to get all three parts in?

>> Matthew Oldridge: Well, so 45 minutes is the chunk of time I have to work with. So in this case, it worked out perfectly to do a problem in the first 45 minutes last week. And today it fit in perfectly to do a consolidation of that. But I think given that the classes are spread out on the ten-day cycle and that they're only 45 minutes, you just have to decide what's most needed on any given day. So in this case, the class is consolidating after a weekend. We gave them a bit of time to review what they had done. And that was just fine. So again, wonderful stuff. Some are down and we're taking them anyway. But we looked at all twelve, right, from two classes. Stunning diversity of problem-solving strategies and stunning diversity of mathematical thinking. And the number of ways to do it, there's stuff that I never would have thought of. The question is extremely open-ended. If you want to think what's fair, you're deciding what's fair. And that was the heart of the problem. So I think that for the first ten minutes at the most you're going to take your chart, just talk about the things that you'd like to say about it. We want to hear the creative and interesting things you have to say.

>> Marian Small: One of my experiences in Ontario -- which is, by the way, the only province that uses the phrase "three-part lesson" -- one of the things we've done is we've turned it into a buzzword instead of focused on "What were the intentions of the parts of a lesson?" That our goal is to help people understand here was the game. The game is before you give students a problem where they do the thinking instead of you. You have to get them ready for that problem in one way or another, and that activation can take many different forms. And there's no right form and wrong form, but you have to get them ready for the problem. They work a problem probably collaboratively but not necessarily -- maybe with chart paper, but maybe not with chart paper. And then in the end, the big part is consolidate. So for me, I think teachers have to be much more thoughtful about "Why am I doing what

I'm doing? Is this structure the best way to accomplish it today?" Would I have a mix of three-part lessons some days but games other days, and some other -- like, some kids are working on smaller problems in stations, but I'm working with a guided group over here sometimes? My answer is yes. So a whole whack of teachers say "Well, should we do a three-part lesson one day a week, two days a week, three days a week?" I could say, like, I don't know; it depends on what you're trying to accomplish, which means is best. So if you're focused on a particular day is for kids to practice a skill, often, unless you pick the right problem, a three-part lesson's not going to do it for you. But you have to know why you're doing things. So I worry that we're selling slogans and we're not selling ideas. So I really hope we get away from "I know you're supposed to do three-part lessons" and I want teachers to say, "So this is what I want to accomplish today."

>> Matthew Oldridge: There's times when you can recognize that you wouldn't benefit from spending more time on something, but I think it's recognizing when it's time to move on and time to stay. I think it's all about balancing what's needed at any given time.

[Inaudible]

>> Just another two or three minutes to wrap up your thinking.

>> So this costs -- it costs less for them than the people who are selling these bottle.

>> Exactly. So it isn't great for them to charge, you know, more than what a Coke bottle would charge, even though a Coke bottle takes more effort.

>> But I think this generally is a lot of money, like, just for a drink.

>> Matthew Oldridge: Everyone's too until the middle of their thinking, they can't stop. I think also not seeing the three-part lesson categories is hard and fast. And in some ways they might blur together. So the minds-on problem turned into a pretty big thing; which turned into a big consolidation; which led to some mini-lessons; which will lead to more problems and maybe some practice; which will lead to the bigger assessment in the end. My advice would be not to get stuck on "Okay, part one should take this amount of time and part two should take this amount of time," or not to try to do it all in one day. Do what you can. And just, like, be very flexible and responsive to the needs of your class. That's way more important than meeting some, you know, ideal world structure of the three-part lesson or any other ideal world structure.

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The Three-Part Lesson - Activating Student Thinking

>> To prioritize, activating thinking is a great idea. There's a guy named Harel from San Diego who talks about intellectual need and the idea that, that people, humans, are all fascinated by puzzles. We're drawn to puzzles and we want to unpuzzle ourselves. It's this natural, you know, way of, of going from disequilibrium to equilibrium, to put students in that disequilibrium is not a simple thing, and it's not just, you know, reviewing last night's homework won't do it. Or even considering one groups work necessarily, the thing to do is to throw students into conflict, into cognitive conflict, which could be showing two pieces of work, and saying like, how are these different? How are they the same? Or to throw one student against another, and say, you both fought these two things differently, can you come to an agreement on something here? Or to throw the student into conflict with the world and show them something odd. There's this weird moment, where it was like, oh, yeah, there's something weird going on here. That's the moment that we all ought to aspire to, puzzle our students in some way, at the start of class, and then, then spend class getting unpuzzled.
>> The great U.S. math voice, Dan Meyer, talks a lot about where the real world math and interesting math can intersect. Because he feels like real world, for its own sake is not the best thing, but real world, stuff that exists, and, and stuff that exists in the real world and is interesting to students is best of all. So, finding where real world and interests intersects is difficult, because we've all been there, where we pull out, you know, here's our area problem of painting a wall, these kids are 11-years-old, they've never had to paint a wall before, or put up wallpaper or tile a floor, they're all like such interesting area examples, but it doesn't probably connect with them at all, because they've never had to go to Home Depot and, and buy the things. So, knowing that we could look at unit rates, the unit rates in all three grades, I was thinking where in my life do we find them, and so that's where I came up with, that should still be here, the photograph of the drink sizes at the movies. Because I think a lot of math starts with the question. So when I was looking at the three drinks, my question was, why does the small one look so weird, basically, it, it looked sad and pathetic really. There's the giant, jumbo cup, you know, the fairly big cup and the other one. So, my hypothesis was the small cup is clearly out of proportion, and I knew that would be true of the price and of the sizing. So, I decided that would be the jumping off point for today and the next two days. And some potato chip sizes as well. But I was thinking the students would relate to buying something, okay, that's in their life. They go, they may, they would go to the movies or the grocery stores, and money, basically. I mean, they need to understand that a lot of things we buy are priced per unit.
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>> The beautiful thing about Mr. Oldridge is that he doesn't use textbooks. He, he tries to figure out ideas, everyday life

situations, and to make us actually want to work and see the world in a different perspective.
>> So it's easier for us to relate to.
>> Like, this, this is math, but in the same time, it's money and it's business, it's...
>> Comparing something you really care about.
>> Yeah, just not like...
>> It's connection making.
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The Three-Part Lesson - Selecting Engaging Problems - Different Directions

>> I think people know that I am committed to these things called open questions. And open questions, to me, means that I really want a child to be able to take it where he or she wants to take it. Not where I wanted them to take it. If I see the purpose of education developing independent thinkers, and that is what I see it being, then it doesn't make sense to me that his answer better be what I wanted. I love questions where a child reads it, and he thought something completely different than I intended and goes to this other place with it.
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>> If the chips are a better deal compared to the other things in the machine? That's an interesting idea.
>> That's something that I feel I could instructionally deal with, because I feel confident enough to do that, and that I think it's valuable because, ultimately, if my real goal is independent learners, I'm kind of supporting that goal. So I could see maybe you can't do it all the time, although you should make yourself do it a little bit. I also think some people don't go that way because they think maybe where the child go won't be productive, and it could lead to a bad thing. So, they're concerned in a positive way about making things better. So, it feels to me that this is one of the things teachers have to practice. They have to practice what if a child goes this way with something when I wanted them to go that way. How am I going to handle that? Once you get better at that, and you can practice that skill and you can get better at that, then I think you don't feel those same concerns and you can let that kind of thing go. I think that my goal in making independent thinkers so overpowers every other goal I have, that, for me, it's always worth that effort. And really, when I ask an open question, a lot of people go exactly where I intended, but there's a few who don't, and, to me, that enriches the conversation, it does, does not detract from it. There's value in kids seeing, another kid saw the same thing I did and thought a totally different thing. I think that's actually a valuable life lesson.
^M00:02:02
[Silence]
^M00:02:18
>>Because what I've been thinking is, I want to know, if I'm hungry, if I'm getting good value for my money or not. Of course if I'm hungry enough, I'm just going to put a dollar fifty in and you may have been in that experience before. It's up to you to decide what's fair. It's not up to the people, the vending machine company or the chip company or to me, it's up to you. Because, again, it's tweet size math. This photograph, the annotations, the tweet itself. And you've often probably taken the time to look. You might know that it's, or you might not know that it's 32 grams, exactly. I just wanted to know what's a fair price, that's the big question, right?

And any mathematical thinking you do is going to support your conclusions, but some guiding questions I had thought you might you want to answer, might, what's the unit price for kilogram? How many little bags would that be? Can you suggest a fairer price? So I feel like answer the big question for sure, but these are just some entry points to how you might do it. These machines are in your life. And we all have a little bit of pocket money, and we have to decide what to spend it on.
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[Background Conversations]
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The Three-Part Lesson – Selecting Engaging Problems – A Variety of Solutions

>> I feel open questions will work a lot of the time. There are times where there may be a particular convention or skill or something you have to teach someone, so like you got to do it. There's like no way you can figure this out unless somebody tells you. So like I can deal with that. I can certainly deal with problems that we often call open routed where there's many strategies. And I think in Ontario many teachers have gotten better at that. There are many strategies to do something. And I think that's great, but I think that if that's as far as you go it's still like, and you better get my answer. And I don't like that to be the only theme I hear.
>> And I went to see a movie. I was looking at the drink sizes. So I'm looking and I'm thinking what's a fair price for each cup size? So I'm thinking just like "Sesame Street", one of these things is not like the other, and I'm sort of looking at how you've got the giant cup, middle sized cup, and really, really little cup. And I'm thinking about the prices. So it's not about how much sugar is actually in this one, although it could be, but the prices specifically. What do we think would be fair? So we may decide they're priced fairly or we may decide that they're not. But what matters the most is the types of mathematical thinking we can do to decide.
>> Well the fair price, it gets us really into the project like there are different ways the movie theatre could price their prices. I guess how they're pricing it is by the business, how much money they need to make, but there's like different standpoints you could view the prices by. So there's a fair one, like what is fair, we have to take a bunch of things into account. We have to look at prices for different stores, prices for different areas. So that's really what got us thinking into what a fair price would be. And then we also did what a reasonable price would be for the project.
>> I think it was interesting because a lot of people had different points of views on it so you could really go any way with the project and there was really no wrong answer because it was kind of opinion, logic, and math put together.
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The Three-Part Lesson – Selecting Engaging Problems – Contextual and Non-contextual Problems

>> There has been more attention in the last number of years on the critical nature of problems in context. There's two drivers really. One is that they are more meaningful for children, both because they feel like there's a point to all this, but also because the context, itself, like helps you figure things out. So context has become an important thing, but I, what's interesting to me is that people who engage in mathematics at higher levels are people who become what we call mathematicians, frequently, could care less about context. What they love about math is figuring out how that works, or figuring out how that works. And that was the driver for them, it was curiosity, it's like, how come that happened or how come that happened? So I actually think for many kids that could be a driver too. And it should be a driver too, some of the time. So I think it's about balance. The richness is its making you think and it's making you kind of figure stuff out and sometimes it could be contextual, and other times it could be non-contextual, but if it's non-contextual, it probably peaks your curiosity in some other way.

>> If you start from your raw materials in the real world and in their world, it doesn't have to just be a math class. Those kind of boundaries are fake anyway, I'm doing math now, now I'm doing science, now I'm doing French, it doesn't really work that way, unless you're in schools and bells are telling you where to go. So, what I think was great about this task was, is that they were making connections to their own lives. For example, some were interested in the fact that you can pay a dollar for a cup at McDonald's. Some were interested in the different pop sizes that are for sale in the grocery store. Some were interested in the business owner's perspective, and some went right to price per litre, it was just so incredibly varied. But so, when it becomes not just a math task, they're more used to making connections for one, but also gathering information from, from the world. So, some of the techniques, some of them used, were looking up the average price for Coca Cola in the world, I have no idea how and who calculated that, but, they were just, they're used to looking for the background. But interest on its own, where if it's a problem for math's sake and it doesn't come from the real world, that can be fine too.

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The Three-Part Lesson - Finishing the Thinking and Planning for Consolidation

>> So if this launch this really interesting project, problem, and the kids start getting engaged in it and it takes them awhile to really solve it and they're trying all different things, and, bingo, the bell rings, what are you going to do? Stop and have a congress? You've got to be able to look at what they're doing, you've got to be able to think about what they're doing, and the next day, when they're not done yet, they need time to go back into that thinking and play with it and refine it and reflect on it and then represent it in a way that it's accessible to an audience. And then the teacher needs time to look at that and think about, so what are the salient points here? And where, what is the progression of learning that's going on?
>> So for 7c, you were the potato chip problem, actually, at the end of the yesterday, we did look at these chart papers. And a lot of interesting math is happening. And you probably don't need your memory refreshed from yesterday, but 32 grams, baked potato chips, a dollar fifty, that was the problem. And a lot of you decided that it was a big problem, because you were looking at things like family-sized bags of Doritos and, and you felt like it was a, a little bit crazy, the price. Think about what you'd like to say, because it's a chance to show your mathematical thinking. We're interested in seeing how you thought about the problem, right? So not just the strategy that you used, but the type of thinking that you did, because nobody else but the people who worked on your chart paper knows how you thought about it. Don't read your calculations. Because we can see them and we can read them, but tell us what you did and how you did it, and we want your conclusions, right? All the conclusions are so different.
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[Background Conversations]
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The Three-Part Lesson - Consolidating the Important Ideas

>> During the filming of this webcast, all students presented their solutions so their explanations and conclusions could be captured for the viewers. As a result, Matthew did not carry out a formal consolidation based on strategically-selected pieces of work. Educators can use this clip to practice creating a consolidation for either the grade 7 or grade 8 classes. There are suggestions and guidelines from experts, as well as resources from Matthew and his students, to help design an effective consolidation. A consolidation that relates to the purpose of the lesson, is responsive to the student's thinking, connects the concepts and explicitly communicates the important mathematical ideas.

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>> I believe that the intention of consolidation, and this is just my spin, is that consolidate usually means like pull it all together. So, for me, it's the notion that I teach a lesson for a purpose, I picked a problem to accomplish that purpose, and my consolidation will bring that purpose to the surface. And no child will leave that room not knowing what this lesson was about. And that's my goal. It's not like this is what Sara did and this is what Marshall did, it's like this was the math idea I learnt today.

>> If I were to think what the big idea is, is that some things, like cup sizes or like prices, might be in or out of proportion to each other, and we notice that. We all use different types of mathematical thinking to get to, get to the conclusion.

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[Silence]

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>> So a series of researchers in the states, Peg Smith and, and her colleagues have talked about the, the steps to produce good discussions in math class, and one of them is anticipating student responses to rich tasks. A key step here would be to, to anticipate the different misconceptions and correct conceptions that come out of a problem, and the best way I know how to do that is just do the problem myself, and, ideally, with colleagues, also, I'm always surprised that I think I've solved this problem every which way it can be solved, and then I give it to a student and they produce something different and interesting. So, it's useful to have the same problem in front of different colleagues to see what comes out of that.

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[Silence]

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>> I actually think of consolidation as I have preplanned questions that have to be answered somehow toward the end of this lesson, but what I do exactly with those questions may be altered or transformed or shaped by what students did. Student activity will change what I do, but I don't go in there cold, hoping like I see something good, I go in planned for these are the ideas that I need to come out, and other stuff is going to happen to it. You set up your task with these

questions in mind to make these richer things happen instead of, yes she did it, yes she did it, no he didn't do it.
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[Silence]
^M00:03:44
But the real learning, the point of the lesson, probably emerges in the discussion. So if I view the purpose of this lesson is not to get the answer to this really great problem, the purpose of this lesson is to see those bigger connections, the consolidation is the important part. Like, and that's where these ideas that you've decided was the point of my lesson is really coming out.
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[Silence]
^M00:04:28
For me, the value isn't so much to be able to say, well I used decomposition and he didn't. The value is that you realize that you used a strategy that would get you further, or you used a strategy that you could apply in more situations. And so it's not for me so much the naming of it, but what is it about this one. It was called this, but like what was it about this that made it good?
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Flexibility - The Three Parts of a Lesson Blur

>> Matthew Oldridge: Here we had their choice initially was cost per millilitre. So I think the key thing to note is that this is the cost per one. So we do call these unit rates. So unit quantity per one of other unit quantity.

>> At the beginning of the period, Matthew summarizes the learning from the previous day's consolidation. He then presents the minds on for the lesson that will occur the next day.

>> Matthew Oldridge: We usually do a great job of creative brainstorming, so I do have some sticky notes. And let's take some time to brainstorm some rates in general. So any rates at all. And again, so in your life -- sports, or sports shopping, music.

>> The average resting heart is 60 to 80 beats per minute.

[Inaudible]

>> Like, your pulse.

[Inaudible]

>> Okay. Now we [inaudible].

>> Say you want to bake a cake and you want more than one pound. Then you can do two pounds converted to kilograms, which would be 0.8 -- well, nine.

>> It's the fastest bird in the world versus slowest bird in the world.

>> Does this one make sense? Does the cents sign go before?

>> Matthew Oldridge: Yeah, they're all good. Yeah.

>> Is the cents sign go here or here?

>> Matthew Oldridge: After. So one C per one gram. Heartbeats per minute is a pretty important unit rate. Yeah, any that are done, just stick them right to the wall. [Inaudible] Yeah.

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The Importance of Practice

>> So where do we go next? We have this inquiry-based problem and the students have been engaged, they've done a lot of very interesting soft skills, from guessing to abstracting and decomposing and problem solving, all this great stuff we want from them. What have they walked away from with that experience, and where do we go next? You know, they've finished a water tank [phonetic] problem, let's say about volume of a prism. They've found the volume of one prism. Maybe two with an extension problem. I don't want to assume that student has a strong understanding of volume of prisms, and I definitely don't assume that they are fluent, they can do these quickly and nimbly, so the next day, we're going to spend some time formalizing the mathematics and then practising it. And then we're going to practice on a whole bunch of just naked number type problems, different kinds of interesting prisms. Tilted on their sides, straight up, those sort of things, and see what students do with those. But I, I think that, you know, as inquiry enthusiasts, we can downplay it, our, our liability is that of downplaying the importance of fluency, and fluency and practice and skill practice is so great once the students have a really strong conception about when will this be useful? Where would I use this? And that's what the inquiry gives us.
>> There's one example in the afternoon class. Like two groups where they weren't, they managed to get something, but were not as confident from the very beginning, in approaching this problem. So those are the sorts of things you make note of, that potentially this type of thinking, for at least some of them. See this is where we, when we get down to doing some individual stuff, it'll become even more evident, but just taking note of that at a, at a starting point, that some may be, eh, maybe, a little weaker reasoning proportionally.
>> And so you just mentioned when you get down to doing things individually, can you give some examples of what that might be?
>> It could look like a bunch of different things. We might go to activities from things like tips and we might just do some of those activities. We might need to turn to the textbook and, and selectively target a few, a few questions. We might have to pull it back to something mechanical, you know, setting up and solving proportions. Like, pulling it all the way back to that. I say pulling it all the way back to that, but that, once we know these concepts, then we need to look at the skills foundation. So some of these kids I mentioned, some of them might be weaker in the, the skills foundation, that might be holding them back. Some of them might be weaker in the reasoning, specifically, this type of reasoning, but we have a whole curriculum and achievement chart that can help us to know what everyone needs.
^M00:02:45
As we left the grade 7's just now, I left them, after the consolidation, I left with, them with some practice from the tips on rates. Which probably after doing it, the problem we did,

realistically, would probably be quite easy, but there was just two pages, probably 8 to 10 different rates, different calculations, different wrinkles, so the practice aspect is there, but as I was saying, they need me less for that part. Unless they need specific interventions, you know, with their understanding, the correct understanding, or if there's major misunderstandings. There's an extra layer added. Are they using technology effectively to capture mathematical thinking?

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[Background Conversations]

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I guess it's new and novel as compared to the chart paper. But new and novel can be its challenge, so students themselves need, you know, more practice and time with their devices to think about how to, to show their thinking. So, a drawback is it can take a lot more time, but I think building the technology into the culture of the classroom definitely helps.

>> If you're thoughtful, you think about what are the things that are really important to practice, so I think there are skills, computational skills that are important to practice. But I also think it's important to practice problem solving. And I also think it's important to practice thinking. One of the ideas I often work with, with teachers, is that I believe one of the, one of the ways they should work with kids is to say something like, so if I tell you this, what else do you know? I think you should practice that too!

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A Mini Lesson Making the Mathematics Explicit

>> Dan Schwartz, a cognitive psychologist at Stanford, writes about a time for telling; like when is a good time for telling?

We have this idea as inquiry-based teachers that all telling can be bad. That we should only ask questions or never say anything a student can say. And he found that that's not the case. That there are effective times for a lecture. And one of those is when the student has struggled a bit first.

>> I think on our math teacher planning journey, now, I would have many possible directions to go. I'm just wondering if, looking at containers again could become redundant. So now I'm thinking, what other examples of rates do we need? But the extra.

And so that's my first consideration for planning, and the second is going to be when we consolidate today with the grade eights. What strategies we use and what mathematical thinking underpinned them, and where will that take us? So what skill development is needed, which could be a simple mini-lesson on actually calculating unit rate, like price of unit something per unit something? It could be an appropriate time to look at setting up two ratios and solving. For example, a cross product. Just for two examples --

>> -- so we found the mean over here and then we decided we should find the ratios for that too. So we took, for example, the large, and we did using cross-multiplying for 82 here, with the amount so from here. And then we took medium, and we did X for the price and then a quantity here. And then you can cross-multiply, and we found the prices for each one. So here we did using the large here, we [inaudible] using the medium, and then here we did using the small.

>> We reached a point where we've done some good work. We've got our minds on this topic. We've seen a bunch of mathematical thinking. You know, the road's pretty wide open for where we could go next, and I wanted to do just a little mini-lesson on unit rate. Sometimes it's useful to calculate the unit rate.

So, a rate is a unit of something, a unit of one quantity per unit of another quantity, right? So the unit rate is going to be the rate per one. Well, actually, let's just set up the rate first. So we had 599 for 1.3 litres was one of our rates. I might want to know the cost per litre and some people did work with that, right? You worked with one litre or the two-litre bottle because those were familiar to you.

So, if I wanted to know the cost per litre, what operation do I do? And there's a couple of ways you could go about it. So, in this case, 599. Does that actually show up? Not really. Divided by 1.3 litres. So we had 4.6077, and that's still in dollars, and that's still per one litre.

So advice I have to give here is we have to round to dollars and cents, because we don't have any more precise unit, and we barely even have a cent anymore. So $4 and $0.61 per one litre.

Okay. This was strategy one, straight up the vision and then common sense should tell us if it's this much for 1.3, if it's 0.3 of litre less, $4.61 makes sense. But let's make sure I didn't make any mistakes.

Let's set it up in familiar ratio form or more like a fraction and let's set it up because we know a bit of algebra in terms of unknown quantities. So let's set it up in terms of x quantity where that's the cost per litre. Cross product or more of an algebraic way of thinking about it.

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[Background Sounds]
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Okay. So the cross product is such that if this ratio to this is the same as this to this, then my cross-multiplication ratios will also be true. And then this ratio to this ratio is also going to work. I had, which grade was it?

Somebody set this up the other day, and they multiplied this and this, and they found that this and this were not equal. Right? So they knew that they didn't have working ratios. So let's think of that again. If this and this and this and this are in a certain proportion, then we can just solve for our unknown, because these relationships will also be true.

All right. So how does that actually work? So it's 599 times 1 litre is equal to 1.3 litres, just times x, right? So $5 and $0.99 is 1.3 litres times x cost. And you know what? We're in familiar territory here. That's an L for litre. Because this has to be $4 and $0.61. We just happen to know that already, but if we didn't, we'd want to solve by just dividing it out. You know, if we've done it right, this should work the same way.

Okay. So 4.6077. So $4 and $0.61 when rounded. Many people tried this operation, but here's what we'd call an algebraic-type prove. I guess, at this point, I'll say; is there any questions about this?

>> So we can pretty much just use [background conversations] units of rates for literally anything? For example, like basketball. Like Ms. Gerald [phonetic] was talking about. You can talk about points for games and his average is [inaudible] point four, which is really close to Michael Jordan.

>> Something I learnt. I actually never realized this, and now is that it's in our everyday lives. Like from what the food we eat to the important things like water and stuff is always good and always [phonetic] needed.

>> Well I never thought about the second way that Mr. Oldridge taught us how to calculate unit rates. I never really thought about using algebra. I actually just divided [background conversations].

>> I also thought that like he uses a similar way of the formula, as we did in the other question about the Coke and about the different cup sizes. Like he used the same formula for division.

>> So I really enjoyed the mini-lesson that you did about ratio. It was very interesting to see the cross-product modelled conceptually. So, I myself was taught it very procedurally, and the way you taught it, you were really able to see the concept behind it.

>> Well, in this case, having worked with the rates, they were ready to set up equal ratios and only presenting that as one of many possible strategies [inaudible] the same mix of tricks. So just giving the trick and say look at this shiny trick. It works every single time, but doing it in tandem with conceptual understanding to show that once you have understanding, this procedure will work every single time but also why. To me that's very powerful. So whereas I was a kid. It depends from year to year. Sometimes I would have been just given the trick right away and it would have seemed like some mystery magic. But it's not magic; it's mathematics so we have to show why it works as well.

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Exploring Mathematics through Wondering

>> So math for math's sake I mean exploring number and the patterns in number or the Fibonacci series or fractals and the things is like recent mathematical kinds of ideas and discoveries and really having a chance to just explore the ideas and to play with them is just as creative if not more so than a context that you made up that kids might be willing to engage in so they can learn to compute more fluently. So the love of mathematics is equally as wonderful as the application as mathematics in the world. If we could give kids entry, explore, play, invent they'll come to the more elegant ways of thinking about it, they might even invent a whole new way of thinking about it that would be surprising and interesting.

>> I wasn't thinking specifically about [inaudible] math I proceeded from the hypothesis is that kids don't get to explore the history of math as much, they don't get to explore the math that is behind the real world around us, you know whether it's the math behind computers or baseball or hockey or anything at all. So I pulled it all the way back to brain storming, questions you can answer with math. ^M00:01:26 [Silence] ^M00:01:35

>> This is what we call the wonder wall and it was a spark of our genius hour projects, so when I initially brain stormed this had no categories, just a whole mass of sticky notes and the question was what is a question that can be answered with mathematics and so for example I wonder how much Justin Bieber makes in a year, could we answer with some kind of mathematics? How much electricity is used per hour in the world, could be answered with mathematics if you had the right tool. How many Tim Horton's coffees are there in the world right now? Will the price of oil be higher or lower in 2014, so the type of things they were wondering about were pretty diverse but what I realized was that one day I was looking at the whole mass and I realized they could be sorted into categories so we could either Google them to find the answer. For example how many pounds of gold is there in India? So it makes it an interesting question but we all have devices and internet so they're easy to answer. We might require an estimation tool to answer them like how many times will one person use the word love in their lifetime? ^M00:03:05 [Silence] ^M00:03:18 So if we had an estimation tool we could come up with a mathematical solution or some that need more exploration such as is there a pattern that hasn't been thought of yet. We don't often as this sort of question in elementary but if it's impossible to divide by zero so that it equals zero then is a number divided by zero really infinity and this is you know it's a subject for mathematicians but it can be a subject for these students as well. A lot of people will write will numbers change values or signs in the future because it is cultural right, somebody invented the number zero, it was invented in several cultures. We have decided that negative integers are the negative sign, it may have fallen down but one student what to know if math was

invented by humans or whether it always existed. Was math discovered or created, so it's still there and this sort of thing, I wonder what the last number is so a couple of our projects dealt with different types of infinity and what that really means. I wonder when pi ends, which is an interesting topic because it doesn't. How many bubbles can you pop on bubble wrap in one minute would be an interesting inquiry so estimate and gather our data. The other thing to notice is the categories between math and life start to blur so they're not all purely mathematical, like how do you win the game of life with love for example. I guess what I realized is like for one you can plan your entire math program just by having students answer questions so a few times I took one down and used it for the day's problem. But what's more than that it's the inquiry and mind set in math so recognizing it's a subject to inquire in as well.

>> That's powerful, that's teaching kids to be [inaudible].

>> Once in a while I'll see people adding to the wall of sticky notes. They actually do care, I mean we think kids can't generate question in math but the very first day there was something about what is infinity and what does it mean, they actually really do want to know and we should give them ore credit for wanting to explore math in this kind of way and that to ask questions in math.

>> I always found it really worthwhile to talk to them about mathematicians and like you would at any historian right you talk about explorers...they're exploring too and the whole idea that mathematicians may take their whole life time to prove of disprove a [inaudible] and I think that gives them that idea that you don't have to come up with the answer right away, it's something that can take a long while to be able to prove or disprove.

>> What we don't do in math education is we don't look at the lives of the people who did math. Of the man who got his head cut off because he was trying to find out if the squares in the hypothenuse actually adds up to the squares on the other two sides, why on earth would his enemies cut the head off that man and not anybody else, unless the answer to that question would have crushed empires. That's what math is all about. ^M00:06:48 [Silence] ^M00:06:56

Exploring Mathematics through Investigation

>> Lucy West: What about investigations? What about projects? Like, where do they fit in, in a three-part model? So there are many formats through which you can really get exciting, innovative learning going on in a classroom in mathematics or any other subject. So when we just focus on format or we think there's one right format, we put ourselves in a box and we become uncreative again. So where's the innovation? Where's the permission to play? Where's the permission to explore something? There are many models that work in lessons. Socratic dialogue doesn't fit in a three-part framework. And so, yes, should there be a focus to your lesson? Sure. How big could it be? You know, could many different kids be working on different things at the same time, that are somehow related, that we could have a congress about? I mean, I don't know. There are many ways of playing within a field that would make sense.

>> Matthew Oldridge: From there, I had students develop their own big question on a topic they wanted, and some subquestions, and to present the work how they like. So we had things such as music in math.

>> So mathematical, isn't it?

>> Yeah. Einstein played the violin.

>> Really?

>> Yeah.

>> I did not know that. Do you play any instruments?

>> I play, like, five. I play the piano; the guitar; I can sing; and I play the flute; and I guess I technically play the recorder. But I don't know if that really counts.

>> So you -- music and math. If you can read music -- can you read music?

>> Yes.

>> Absolutely. That's reading math, isn't it?

>> Technically it is because, like, quarter notes, like, one-quarter of a beat, which is a fraction. And then, like, the time signature's, like, an eighth note, for example, gets one beat. So like six/eight time. Like, I guess that also counts as math because you'd have to be able to count up the amount of beats in a bar, figure out stuff like that.

>> And there's something interesting about it because when the time

signature changes, what happens to the value of the notes?

>> Yeah, either -- well, okay. Sometimes they stay the same and sometimes they get, like, bigger. Like, if it goes from six/eight time to four/four time, the entire mood of the song changes. Whereas, like, six/eight time is, like, swing, I guess you could say. Whereas, like, four/four time is, like, straight and steady.

>> And what would happen to a half note?

>> A half note?

>> In six/eight time versus four/four time?

>> Half notes aren't really in six/eight time because it's not three beats, so it's not really swinging. It's just sort of there. And well, if they were, it would sound a bit weird -- although I've seen it before. Well, in four/four time it fits in, like, perfectly because it's, like, two beats. It's even.

>> That's great. Thanks for sharing that. So you have many talents; have you got to be able to express them through your mathematics as well?

>> Matthew Oldridge: We had something to do with "How much fat should the average person consume? What happens at the speed of light?" Which is relativity. We had some amazing ones deciding who would win the NBA championship based on statistical methods. A bunch of soccer ones -- same idea -- what's the better player? Who should be on the Canadian Olympic team and who should have been left off? Again, based on statistics. And I did want to emphasize that they came up with the most incredible methods for exploring math, like, advanced statistical models where they decided who was going to win the NBA championship based on their own statistical models. So that all came out of this.

>> I wrote several things on the Wonder Wall. You know, there was the question about sports. I really like sports. So, like, a few questions about how Sidney Crosby and [inaudible], like, stand up against each other in, like, sports and their statistics. Most of us had like a project for what we wanted to do, like, our own mathematical projects. And yeah, I did a project on that. It was about the statistics, like, shots per game for Sidney Crosby and, like, goals per, like, on average every season.

>> One thing I love about this class is in grade five and four, I wasn't a big fan of math. But Mr. Oldridge incorporated something that I love -- which is sports -- into it. And my latest presentation was about baseball, which I play. And I found it so much fun just to be able to see all the mathematical stuff in sports, just by itself statistically-wise and all that. And Mr. Oldridge really opened that

door for everybody.

>> What he does, he takes your interest and then he tries putting math into them. And actually he would, like, mould the math to all the interests.

>> We actually get projects where our minds are put to work. And, like, different, like, subjects, like -- and not just using just, like, different math topics; we can use, like, things from the outside word. So we can do, like -- if we really love basketball, we can always do things, like, we can always learn about basketball. We can always, like, add math into basketball.

^M00:05:11

>> Like, I did speeds and they did, like, different things, like, with the universe and stuff like that. We got to learn, like -- when they presented, we got to learn, like, think about subjects and stuff like that.

>> We have our Wonder Wall here. And we were told so write down "What do you wonder about?" So there's some questions on here. And we organized and took a mathematical question off of it. And there's actually - well they're not all here now. [inaudible]. And the one that I chose was on that, too. So you choose one and then you do your research. It was more of a freelance project. It lets you explore math yourself. And even though there's no set limit, you still learn a lot. I was doing originally a project on infinity and if it had a limit. And -- but then it doesn't have a limit, which is pretty obvious. When I Googled "infinity" and "limits" into a search engine, what came up was a whole bunch of infinite limits in calculus. So I did some research, I watched some videos, and all of a sudden my project turns from just "infinity" into "infinite limits in calculus." So the graph, the functions and the gaps. You can't divide anything by zero. It's a mathematical black hole. You can't. It gets sent in, there's no way out. It's a paradox.

>> Matthew Oldridge: So Genius Hour Math was them communicating their mathematical thinking about something that they picked. And it was truly, truly inspiring work. It exists in the corporate world at Google where they call it "Twenty Percent Time," where they believe that employees exploring their own interests leads to innovation. And it does. I guess it's sort of the independent research project can be in the math classroom as well. But it's more than that.

>> Anna Presta: It's very differentiated, too.

^E00:07:12

Puzzles and Games

>> So one of the ways that I work with students and others is to design puzzles for them to play with. Here's a simple puzzle. These two pieces go together, and they make a tetrahedron. And it's much, much harder than it looks. Some people take a half an hour or more to put these two pieces together because I've optimized them to be as hard as possible. I've applied mathematics to make them difficult. But the key idea in my mind is that people need to get comfortable with solving new challenges when they don't know how to do it. And, as you move up in mathematics, you know, people ask you to prove theorems that no one's ever proven before. And to get comfortable with something that you don't have a cookbook method, it's great to play with puzzles and try different things and to fail and fail and fail and fail. And then you try something new and eventually something works. And that perseverance, that skill, that ability to hit things from different directions is essential. When people work on a puzzle like this, they are building up some kind of ability in their mind that enables them to get better at it. At first it may take them an hour to solve this; but then I'll give them some other ones, and they'll get those faster and variations will get faster. So something does build up with practice. What I have here, because it's a star and it has these five magnets in it, I can put it back together different ways. You can turn it. There's five different ways it goes back together. And it's a wonderful puzzle to visualize how does this roll. When I put this on a surface, how does it go? And it's a simple object that you can look at and, yet, it's so hard to visualize. And it's great to do visualization exercises because there's certain kinds of problems that are best solved by seeing in your mind a kind of a structure. And, by practising on as many different visualization problems as possible, you can build that muscle in your mind. This is something which I brought which is a rubber band tied in a knot. So this started out as a simple loop, but then I did something which turns it out to have a knot in there which is fundamentally unremovable. And it's a wonderful puzzle to think about how can you create a knot in a rubber band. A simple way would be to take the rubber band, cut it, tie a knot, and glue it back. But I didn't do that. There's another solution, and I'll leave you with this as a challenge to ponder over. How do I put a knot in a rubber band? And, if you want the solution, you can go to georgehart.com and you'll find the answer.

>> One of the best ways to practice actually on math is through an exciting math app or a video game. They give kids loads of opportunities to practice, and they're enjoying it at the same time. So I, you know, say to particularly elementary teachers, get rid of those boring worksheets that turn kids off math, and get them working on this app where they're using the same math facts and numbers but they're really engaged and enjoying it. ^M00:02:41

>> It says that in 2048, so it's basically this edition.

>> What's the goal of the game?

>> The goal is to get the highest score over the tile 2048.
>> Okay. Oh, I see. Okay. So show me how. Go ahead.
>> Basically, you want to get the highest number possible, so to do that I have to do 2 plus 2.
>> 2 plus 2?
>> 2 plus 2 over here.
>> Yeah.
>> Slide down makes 4.
>> Yeah.
>> And now you have to try to find more tiles that match. I can make a 4, another 4; and then I can make that and 4 over here. Slide this way and make 16 and 32
>> 32 plus two 16s. 32, 32. Yeah.
>> I can make --
>> You've got to get a 64. There's one. Okay, good.
>> Powers of 2, though. All powers of 2.
>> Well, I'm using Minecraft to build, like, a model of the [inaudible] so I can find out the exact amount, and I'm also doing multiplication in math to find out how it will work. This is the app called Minecraft. Minecraft is like -- kind of like a universe made out of blocks. This is some major league educational gaming.
^E00:04:07

Assessment for Learning

>> According to the policy document, Growing Success, teachers are to use a variety of assessment strategies to elicit information about student learning, adjust instruction and provide feedback. These strategies are to be triangulated to include observations, conversations and products.

>> When it comes to assessment, if I start by presuming I know the [inaudible] end point of this class or this class that's probably not going to be flexible and responsive enough to their needs. So if my overarching assessment purpose is to know them and to draw conclusions about how they know the math and how they've learnt it, I probably shouldn't have a fixed end point in mind. It's not like getting in your car and driving from place to place, it's a different sort of journey than that. I think it guides your lesson planning because you wouldn't spend time on things that are wholly unnecessary. It actually really helps you find the sweet spot of difficulty and where you actually need to be. In general the more that students talk to each other and the more you talk to them the more you know about them. The right observations and the right conversations, group work, gives you just better, better data I think than just working individually. As I said in this day and age with mobile devices and things it's pretty easy to gather that data, you know, snap a picture of somebody working if you think you're going to forget. One thing, but most of all just talk to them, just talk to them and you'll know. Talking is the key and you can correct so many misconceptions in the moment, like there's no reason to wait till later, you know, after a test or something because if you don't know the stuff or you don't have the concepts going into the test you're still not going to know it on the test and then you're starting this whole other horrible cycle based on not knowing something for a test. So along the whole journey, I guess, I like to make sure everyone comes with me.

>> One of the things that I'm finding very interesting is a finding from neuroscience that math should never be associated with speed, so this is a very interesting research finding. They can now scan brains and see how they work and when people are anxious, their working memory is blocked, you can't access it, so what they find is you can be made anxious by math in all sorts of ways. Often I've experienced this where you're like working out a tip or doing math publicly with people watching and you suddenly feel like oh, I just can't think; that's the impact of stress blocking the working memory. So whenever we give kids stressful situations, timing exams, they actually can't function. The kids, you know, they develop this anxiety and they cannot produce math and what happens then is they start to believe that they can't do mathematics, so I think the research that we're getting on speed from neuroscience is really interesting and important.

>> Do you have a lot of tests in this [low audio]?

>> No, he, I feel like he's a teacher who doesn't do a lot of tests, he's a teacher who really likes assessments because in tests you can't really show all your thinking because there's like a time limit. In assessments he, we all really like to show our thinking and really show what we can do, so I feel like it's much better than doing tests.

>> So instead of having a test like it's better like, I personally think it's better to like do like problems like this one. In a test you have to memorize it all in your head and at the end you forget it all.

^M00:03:24
>> We have a lot of assignments and like projects and but we don't get very many like tests in class. I prefer it like that because it's, I find it easier to be able to like think about something over a period of time rather than just like, because sometimes people get a little nervous during tests and they just freeze and you can't like think of anything to say or do, and then with a project you have a bunch of different like, I don't know, you can have time to finish it all and complete the work.

^M00:03:48
>> Sometimes you now the mini-lessons will help solve their problem but sometimes they just need specific, focussed one on one talks.

^M00:03:57
>> He's not really harsh on you if you don't know the stuff. He would go easy at your own pace and at your own level to slowly go higher.

^M00:04:04
>> To what she was saying like when we're frustrated like it's hard. Like even for me like I have trouble when I get frustrated, I'm frustrated and I like completely stop what I'm doing, I have a total breakdown, but then like the way he shows us like to do things and he stays calm.

^M00:04:20
>> Once you have a collaborative culture they're also used to helping each other, so the specific remediation where somebody just doesn't get it doesn't happen as often because we all move each other along or pull each other along.

^M00:04:36
>> So do you think Mr. Aldridge [assumed spelling] has a good idea [inaudible] all doing individually in the math class?

^M00:04:42
>> I think so because he always is observing what we're doing and it's

not like we're keeping it all to ourselves, and we do present it in class as well so that he is aware that we are doing the work and not just goofing off.

^M00:04:54
>> And he also collects some of the problems and marks it and we get our marks back and he like writes what to improve on.

^M00:05:03
>> But it also depends on the person like the person doing the work because if you don't interact and you're just doing it by yourself on Minecraft or some other, on your electronics, then if you don't really share it verbally or visually then he doesn't really have a good idea.
^M00:05:19
Like it's basically a lot of like what you, it's like a lot of your contribution and before it used to be a lot of what the teacher, you just write it down, give it to the teacher and then they know, right, but now it's a lot more of like your responsibility to tell the teacher what you know or [inaudible].

^M00:05:37
>> They're getting assessed, they're getting the marks and they feel very confident in the fact that their teacher, through the conversations, knows them very well.

^M00:05:45

[Silence]

^M00:06:04

Assessment and Technology

>> We also need to recognize that in this day and age, and this is what's got really, got me very excited at the moment, we have the technology at our disposal, at our fingertips in terms of we've now got through hand held devices, smartphones, tablets and accompanying software, we have the capacity to address what formally had been issues around oh but if I simply observe students problem solving and then mark it when I get home, it's going to be unreliable, it's going to be so subjective. We now solved that problem because we've now got the tools relatively accessible and affordable to enable us to deal with that reliability problem, but what needs to occur, of course, is a mindset around this.
>> This whole way of capturing your thinking on a screen for math, I do believe is very new and very powerful.
>> When we think of the paper products that we were kind of observing throughout the day what you lose sometimes is that process that the students were using to solve the problem but the technology allows that archiving of that and the capturing of that student thinking, so yeah that is a game changer in terms of.
>> It can be, yeah, especially if we think of the assessment, so knowing where they're at, if we have recordings of their thinking, it's never lost for sure.
>> Yeah it used to be that we'd have a portfolio of student work that we could share with the students and with parents and now we can have a digital portfolio of their work and you know it goes back to what we were talking before about those conversations and observations. Now you can kind of have an archive of those things that you can always refer to.
>> For sure.

Assessing Mathematical Thinking through Observations and Conversations

>> I interact with teachers. We -- they talk to me a lot about levels. I talk very little back to them about levels. We say that assessment should drive instruction but that could mean two things; for some teachers, it means like if it's not on the assessment, don't even talk about it. For some teachers, it means think about everything a kid says and is it level one or is it level two but for other teachers, it means that I want to know what I really want a kid to be able to do and so that should drive my instruction so that's how I interpret assessment driving instruction. So when I'm listening to a kid, I actually believe you should refrain from leveling most of the time and every once in a while, there are these things called report cards and you have to do something and you do have to say something. You should always be informing kids about how you are reacting to what they're saying and we call that descriptive feedback or constructive feedback, which is quite different than leveling so I think that the attention lately to focusing more on the nature of the feedback you give people, the descriptive feedback, the constructive feedback is so much healthier than leveling.

^M00:01:07

[Silence]

^M00:01:33

>> millilitres on average.
^M00:01:38
>> Can of pop.
^M00:01:39
>> Pop can.
^M00:01:39:15
>> Oh that works to.
^M00:01:41
>> Phrases it better.
^M00:01:43
>> Yeah but can of pop.
^E00:01:45
^B00:01:48
>> Yeah here we go.
^M00:01:50
>> 12, 12 oz.
^M00:01:52
>> So 355. 355.
^M00:01:55
>> That makes. Okay.
^M00:01:58
>> Wait don't. 355 times 12 times 2.
^E00:02:01

^B00:02:03
>> But where do I put the millilitres then? Wouldn't it be like 3 times 12 times 355?
^M00:02:10
>> No it would be because it's --
^M00:02:12
>> Does it really matter if we multiply them differently?
^M00:02:16

>> Sometimes. Because its 2 boxes of 12 cans and that one can has 355 millilitres. So 355 millilitres. Then that's times 12 and then that's times 2.
^M00:02:33
>> So where do I put? Then millilitres it won't continue to list.
^M00:02:38
>> It kind of will.
^M00:02:39
>> No because it will only be at the end.
^M00:02:41
>> We could have switched this around. It's not a big deal.
^M00:02:46
>> All right.
^M00:02:46:15
>> Okay. 355 millilitres times 12 times 2.
^M00:02:57
And that's the ratio to 12.
^M00:02:59
>> $10:00?
^E00:03:01
^B00:03:04
>> Okay now we just need our list right?
^M00:03:06
>> Yeah, we only have 5?
^M00:03:07
>> Now we need to convert all that into -
^M00:03:10
>> Oh my gosh.
^M00:03:10:15
>> Common denominators?
^M00:03:14
>> Kind of. Common ratios.
^M00:03:18
>> Are these even fractions?
^M00:03:20
>> They're not fractions.
^M00:03:21
>> They're ratios.
^M00:03:23

[Silence]

^M00:03:47

[Background Conversations]

^M00:03:50

>> That's a big difference.
^M00:03:51

>> Okay so wasn't that -- that's 3,000?
^M00:03:58
3,000 plus 3,000 plus 3,000 plus 3,000 plus [inaudible].
^M00:04:03
Oh okay what if we do it like -- you know how 15 is a multiple of 3 right?
^M00:04:07
>> Yeah.
^M00:04:09
>> Yeah we can buy 500 bags for that much.
^E00:04:12
^B00:04:15
>> Okay so if we buy -- that's like a 5 times increasement. So 150 cents like divided by 5.
^M00:04:28
It should be 30 cents at the factory plus minus a few cents. Yeah should be around 65 cents.

^M00:04:36

[Silence]

Reflective Thoughts

>> So, we have actually a lot of research evidence showing what happens when people teach math differently. So, a lot of schools use a pretty traditional model of math teaching, where our teacher stands at the front and tells methods, and students practice them. What we know about that approach is a lot of students, some students are good at that, some students aren't, and more importantly, some students are willing to engage in that and a lot of them aren't, so they see it as boring, not connected to life, they're just sitting there rehearsing, practising methods. So we also, we've studied students who go through those traditional teaching, and experimentally compared them to schools and students who are similar, but they are going through a different kind of teaching. So what we find is when mathematics is opened up, which is what I call multidimensional math, when the whole of mathematics is taught, students do a lot better. So, what that means is math teachers in multidimensional mathematics, instead of just saying well math is answering methods correctly, they think, well what is mathematics? What does a mathematician do? You know, they have to ask good questions about, to conduct sort of inquiries that never happens in math class. They have to connect different methods, they have to use different representations, they, they are creative in their work. So, when math teachers say, okay, we're going to teach this broader mathematics, it's a huge win/win situation. The kids do better, they score at higher levels, but also they're learning the math they need for the world, which is really important as well.
>> It's just have the most balanced possible math program, have fun with it, understand the concepts as well as you can yourself. Look for math in the world around you, find it, bring it in, don't just rely on your textbook or any other resource. Make the math come alive.
^E00:01:52