Leanne: Welcome to Maths talk by and schools where conversations in maths become part of your professional learning. I'm Leanne McMahon. School Maths advisor at AMSI and today's episode looks at one of the proficiencies in the Australian curriculum and a vital aspect of great maths, classrooms, effective and collaborative maths problem solving. To guide us through this huge topic, I'd like to introduce Michaela Epstein, founder and director of maths teacher circles and an educator I'm absolutely delighted to have on the podcast.

Welcome Michaela

Michaela: Leanne, thanks so much for having me. It's a pleasure to be here.

Leanne: So before we get started on our problem solving discussion, can you give our audience an insight into your career and what makes you tick mathematically speaking?

MICHAELA: Sure. So as a new teacher I had a, I think common desire that I would say a lot of other teachers feel when they're stepping into the classroom for the first time. And that was that I wanted to share my love of maths with my students. When I grew up, my strongest maths memories were of doing puzzles and playing mathematical games with my nana. She really enjoyed maths and it just felt like a normal and fun thing to me to also engage in it and think about interesting maths problems. So that's what I really wanted to pass on to my students and um I'm secondary trained and I remember stepping into the classroom and my early experiences where I think it was quite eye opening. So you know what's quite typical in my classes was I had this enormous spread, enormous spread of capabilities, but also confidence and enthusiasm for learning maths and I found this particularly frustrating because I didn't know what to do.

I really wanted to help my students to learn maths effectively, but also to find it a subject that was meaningful and relevant for them. So I was quite keen to learn from other teachers and not kind of, you know, spend hours wading through google and trying to figure out what might be good to take into my classroom or not. But I was working in a rural town at the time where not only did we have a chronic shortage of maths teachers, but we also had very, very few professional learning opportunities in maths.

So since then I've kind of soaked up as much as I can while I was teaching and also through other opportunities. So I've been a President and board member of the Mathematical Association of Victoria, where I've been able to see teaching and learning from a system perspective and how different parts of that system operate together. I've also been state representative for the Australian Association of Maths teachers where I got quite good insights into teachers nationwide and I got to see how some things are really similar, no matter where you are in the country, but also other things are so very different.

And so they're just kind of these bits and pieces that I've slowly collected over my career.

I also did masters research at the University of Melbourne and through that I found that a maths curriculum through its design can communicate something that's quite different from its intended goals, which is something that I think teachers grapple with every day. And sometimes that's kind of a subtle grappling, but it's something that's very real and I've also had some opportunities to work with primary and secondary teachers, school leaders, government bodies, edtech startups and kind of like through this very broad range of experiences, you know, realized how wonderfully complex education is, but really at the end of the day that the most important thing we can do is to invest in one another.

And so I suppose it's with this background that I then came to founding maths teacher circles which is all about giving teachers primary and secondary access to others who have practical maths teaching strategies to share. We carefully design our learning experiences to provide welcoming and empowering space for teachers where they can spend time actually doing maths together. And talking about classroom teaching strategies, it's a wonderful opportunity because there's always new ways that new ideas that people bring and insights that they get. And it's for me now years on from that first, it's helping me again to realize new ways all the time that I can share that love of maths with others,

LEANNE: It sounds fantastic. People will realize, remember last week on the podcast we actually talked about where to find your professional learning and mostly we talked about where not to go and that was interesting what you said about, you just didn't want to google it and find it, you needed to actually find someone who knew what they were doing and shared that information. So it sounds like we're really on the same page there and that the teacher circles the feedback that I got from my friends who have been involved with them, they just love them,

MICHAELA: I'm very glad to hear it.

Yeah, I guess I'm a strong believer that teaching thing is such a tough job and there is always more to learn and the more we can support each other and help to lift each other up the better and sure googling at times will be a viable strategy. But if that's your main one then that's a really big challenge, particularly for new teachers.

LEANNE: That's right.

So let's get onto the problem solving. We're talking about effective problem solving. So what is effective problem solving and how do we know it's effective?

MICHAELA: Great question, Leanne. I'd like to first start with what problem solving is in the first place. It's one of those terms that gets bandied about a lot and I know means different things to different people and I like to draw on a definition from mathematician Paul sites and he says that problem solving is the difference between a problem and an exercise where an exercise is something that you know how to do already using whatever approach, whereas the problem is something that you don't know how to do, you don't have a formula for. So as a result, problem solving inform involves things like making conjectures, trying out different strategies, not knowing which strategy is going to be the most fruitful, testing your ideas, collecting data and looking back and maybe verifying validating or adjusting your approach. And often we open up resources and say problem solving as being associated with something like a worded problem. And I would say that you can have very effective problems that don't have any words at all in them or sometimes they do.

So to me really, the heart of problem solving is about the processes that students engage in around that conjecturing and drawing on different strategies. But getting back to your question of really what makes something effective to me.

I argue that an effective problem solving experience is when students have an opportunity to engage in a problem that feels meaningful for them and it can be a problem that uses a real world context or maybe it's imagined and it's just to do with abstract mathematical ideas, but it's a problem that a student becomes interested in it and they want to pursue and then they have an opportunity to draw on strategies of their choice.

I think something that I'm not going to say the worst thing, but something problematic for students is when we try and dictate the approaches that they use. Sometimes those approaches will make sense to them,but sometimes it's not going to connect with their prior understanding at all and that can cause a great deal of confusion and it can also stop them from being able to kind of form important connections for themselves.

Other things that I think are important to touch on here, that effective problem solving is not about teaching concepts or procedures, so like concepts like you know understanding equivalent fractions or procedures like you know how to solve to multiplication, those things can get reinforced and students can make important connections through problem solving but that's not what the goal of problem solving it is about. The goal is about being able to follow mathematical processes and strategies to do with asking questions, verifying your ideas, drawing conclusions and justifying the conclusions that you get to. I also see that problem solving is not about providing no direction or support. You know, just letting students go off and do something on their own and you know, you just stand back and see how they go. I think that can be a terrifying experience for students and often not that helpful or even potentially a bit harmful for them. But instead, in effective problem solving. The teacher has a really important role in terms of providing question prompts that either help students to make sense of their ideas or prompt them in new directions that kind of push their thinking even further. I think a bit later on, we can talk more about what the teacher can do in problem solving situations.

LEANNE: So how might a teacher get started in problem solving?

MICHAELA: I think it can be a really daunting experience when you're not used to running open ended or low floor high ceiling problems in the classroom. And over time I've learned from teachers who are quite experienced in what they have done. And so there are some strategies that they use that I now recommend to others and the first one is to start small. So to not just run the whole lessons of a problem but instead do it in bite size chunks that are manageable for yourself and manageable for your students. And so it could be like 5 to 15 minutes and a lesson and you might do the same problem over repeated lessons where it's just broken up or different problems and that connects to a second strategy which is to do it regularly a bit like any new skill. With problem solving, it's something for your students and for you to get used to over time. So build it into your planning and find that time in the week or time every few days when you can support your students to engage in meaningful problem solving.

LEANNE: Could you do it in like 15 minutes in a classroom?

MICHAELA: Yeah, absolutely.

I think that's a very viable thing to do and you might just give students a small provocation to think about for 15 minutes. But then in a subsequent lesson, get them to build on what they've already done or to analyse Pierre's work or to ask some questions about the classes findings and in fact in some ways those bite sized chunks can be really powerful. I don't know if you've got experiences of solving whether mathematical or other problems yourself that you can think of, but I think it's quite a natural human tendency when we've got a difficult problem to do a bit, walk away, you know, let it sit and just ruminate over it for a while and then come back and actually that process, often a lot of connections will then happen and it's exactly the same for students with mathematical problem solving.

So there are a couple of other things and they kind of build on these ideas that I've mentioned around starting small and making problem solving a regular part of your classroom practice that I've learned really helpful when you're getting started. One of them is to reflect on what you're doing and kind of be patient with yourself when it doesn't go okay. I think that's quite an inevitable thing and you might even, you know, after each lesson just spend a couple of moments jotting down one thing that you'll keep the same, one thing that you'll stop and one thing that you'll start the next time you do one of these lessons.

And the final thing that I suggest is that you try out the problems yourself so that you have an understanding of them. And this is something that we kind of very deliberately incorporate into maths teacher circle sessions, which is time for teachers to engage in problems, to step into student shoes and feel the successes, but also the challenges and frustrations. And that process allows you to much more meaningfully understand the problems that you're then going to share with your students and sort of what the stuck points might be. But it also helps you to build your curiosity an enthusiasm for it, which I think is such an essential part of sharing a problem with others. If you're not curious about it, then chances are your students won't be. There's a whole world of fascinating maths problems out there. So if the one that you've got in front of you doesn't take your fancy, then maybe find another.

LEANNE: So we know we've been told that problem solving is an important part of the teaching and learning of maths, but how does this marry with the explicit instruction approach that we've also been told is absolutely vital, is it an either or situation?

MICHAELA: I love this question.

I often see people feeling a bit nervous when, you know, problem solving and explicit instruction are brought up as if there's some sort of fist fight that's about to happen. But it's such an important one because they seem like such different teaching practices, but I actually said that both super important for students learning experience and you know, Leanne at the start, you mentioned the proficiencies. The proficiency is really about what successful learning in maths can look like. And it's deliberate in having a range of proficiencies, problem solving, fluency understanding and reasoning and also productive disposition and all of those things needing to be in place for successful learning.

There's an analogy that I often like to draw on when I'm talking about this balance with teachers and it's to soccer. So if you think about learning soccer or if you haven't learned soccer, maybe think about another sport or musical instrument when you're learning it, you have to practice. So you have to practice kicking the ball, you know, shooting for a goal, dribbling it and a bit like in maths, you also have to practice. You have to practice, you know, laying out your work, doing some sums, you know, using tools such as rulers, all of that, but you don't practice in isolation. In soccer you have your coach who gives you guidance and then watches you and introduces new skills and tactics to you and helps you get perspective on how you're going and similarly in your in maths. Your teacher will explain ideas, show ways of working out that can help you to make sense of what you're doing and introduce new skills and concepts that build on your current levels of understanding, but you don't practice and you don't get guidance in soccer just to do those things. You do it so that you can have some fun and get out on the soccer field with your friends and you know, get competitive or just enjoy a game on a Saturday afternoon and exactly the same in maths you don't learn and you don't get taught just for the sake of practicing things, you learn it so that you can bring those skills together and engage in wonderful creative problem solving experiences and put your ideas to the test.

And, you know, this to me is where the real balance between problem solving and explicit instruction comes in. Now, what that looks like in the classroom and how often teachers spend on one or another type of classroom experience is entirely up to them. It's up to what they feel their students need and what their timetable looks like.

You know, there are some pragmatics of the classroom situation. I think that we shouldn't be strict in dictating what the right balance should be for learning maths, but that's where teachers can really use their expertise and kind of carefully observe where their students are out and what sort of experiences are going to be valuable for them.

LEANNE: I agree wholeheartedly with that and it certainly has blown me away, that there seems to be this either or approach with explicit instruction and inquiry learning.

MICHAELA: Yeah, I think that one of the fascinating things is that you go into any classroom and it's never going to be an either or like even if you feel more strongly about one of those teaching approach, you're almost certainly likely to be adopting the other as well. Plus a myriad of different techniques.

Sometimes when people sort of talk about getting back to basics, they think of explicit instruction rather than a lot of the other stuff that we do, such as the problem solving the reasoning, all of that.

LEANNE: So what's the importance of collaboration in problem solving?

MICHAELA: Good question. I think that collaboration, you know, a bit like I was saying before that we have this natural tendency often to want to leave difficult problems, go away and come back. I think we also have a natural tendency to want to talk about problems that we're working on with other people. Not everyone is like that, but a lot of us and I think when there are the conditions in place for collaboration to occur in the classroom, it can just open up so much for students so much in terms of their confidence, but also the connections that they make and kind of the new insights that they're able to get. At maths teacher circles, we have what we call a set of maths considerations that sort of guide our conversations that teachers have together. And one of them is to help others understand what you can see. And we talk about how in the breakout rooms that people go into they're going to have others there who have different experiences. Maybe they teach in primary or secondary, have been teaching for decades or only a year, they'll have different levels of confidence and you know, all of that into the mix. And so naturally what is an insight to one person isn't necessarily going to be an insight to someone else. And so we ask they take that time to help the others that they're in the room with to understand their perspectives. And so at the end of the day, a big part of what this is trying to do this mass consideration is to make the space safe for collaboration and for people to share what's on their mind. And I believe that exactly the same applies to classroom with students.

That collaboration isn't something that should be forced, but it should be something where there are conditions in place where students feel safe and where it seems to make sense for them to work with their peers. I've got a couple of examples here.

So there's one problem that I quite like. If you imagine in your head a square and there are lines drawn through the diagonals to create four triangles of equal sizes and the problem is to take those four triangles and cut them out and create as many different shapes as you can with those triangles.

Now, if you're told to work on that problem alone you probably do okay and get a number of solutions.

But then if the teacher, if you're standing in front of your class, you said “with a partner, see if you can find at least five different shapes or working on your own for a few minutes and then talk to your partner about what you found, see what's similar, see what's different” and those sorts of little prompts make it easy for the conversation to start, but then also helps students see how they're thinking, connects is similar is different to their peers, but also why they're thinking is justified and valuable. And the more we can kind of respect students ideas, the more empowering it is for them.

LEANNE: One of the most common questions that I get from teachers is if students are collaborating, how do I know that it's the students work and how do I assess their understanding,

MICHAELA: I really like this question because to me it opens up a good conversation about what are you trying to assess?

What's the purpose?

And a bit earlier, I talked about how in problem solving, I don't see the goal around trying to teach new concepts or skills, but around engaging in want of a better word problem solving processes, you know, around conjecture and collecting data justifying conclusions and so forth. So I don't think the assessment in problem solving is about what students are doing on the spot necessarily. So like a performance assessment, but rather their reflections on it. For example, you can get students to explain their ideas to you at the end or to write a reflection and asking them things like what strategies did you use, explain which strategies were helpful and which strategies did not help? What's the conjecture you had? Did you prove it? Did you disprove it? What are some more questions that you have remaining? Problem solving is something where it is incredibly challenging and there is quite a sophisticated level of thought, but even primary school and early years learners can meaningfully engage in it. So this sort of assessment is helping students to kind of draw out their thinking and then make sense of it in a way that they can then build on it next time.

LEANNE: Sounds like to me your observational assessment is going to be really important.

Walking around with you with your exercise book and hearing what is being said and seeing what's being done and that sort of thing rather than did they get the answer?

Yeah,

MICHAELA: 100%.

The answer is important insofar as were students able to follow strategies that got them to a conclusion and can they justify that conclusion, but if they didn't get to that answer, that's okay. What you care about is the logic of their ideas and being able to kind of make sense of their ideas for themselves, not just copy someone else's thinking and I think, you know, it will become very clear through a reflection process. For example, if they've just kind of sat on the edges and followed what someone else has done, but your point around observation and going around the kind of making notes as you're going, I think is also really important part of a teacher's role during problem solving, where you just kind of see what's going on. Provide, kind of prompting questions and support as students need it. But then also note own what students are doing, those observations are then drawn together in the wrap up.

So the concluding phase of the lesson and that's often where students actually learn the most you have an opportunity there to then strategically drawn different students with the room to share their

solutions and explain what they've done and by having walked around the room and seen what's going on, you can say, “all right, let's start with this solution.” It might be one that students can grapple with more easily and then you build up in kind of increasing levels of sophistication.

So you can be a bit clever about it instead of just, you know. Asking for hands up who wants to share. You go into that wrap up stage of the lesson quite prepared and carefully drawing out which gets to the conversation, you think will be relevant in so many classrooms.

LEANNE: It was often the weakest students that were actually coming up with some really interesting ideas, maybe not ending up getting the final answer, but coming up with some great ideas and these kids aren't the ones that are offering to give their answers. And some of the stronger kids were really reticent to get involved because they know the rules, they know the processes and this something that they couldn't do automatically, really held them back.

MICHAELA: Yeah. It's interesting what happens when we kind of change the meaning of what success can look like in the maths classroom and, you know, I say ‘weaker students’ in inverted commas, you know, I think they are typically the ones who have more trouble following the procedures, sometimes that's because there are gaps, so maybe they don't yet understand multiplicative thinking or other big ideas and so that's holding them back. But what it means is that those students often are required to think in different ways and you use different tools than those students who can follow all the existing processes that they've been using in classes wouldn't consider drawing on.

And I think that's why in the example that you explain Leanne, that you've got those different experiences of students in the class to what they might typically experience.

LEANNE: You mentioned primary school and very, early years as being able to be involved in problem solving. Does problem solving differ in primary and secondary classes?

MICHAELA: I think it can be different. It probably does typically differ but that it also doesn't need to. Let me explain a little bit more what I mean by it doesn't need to differ, in that often a viable maths problem in a primary school classroom can be equally viable in a secondary classroom. So let me think of an example um where at the last maths teacher circle session, there's secondary teacher and Maths Leader Sam Hallisey and she presented a problem to us around looking at patterns in pascal's triangle. And it got incredibly sophisticated drawing on all sorts of high level maths, but it was also starting from a base that was accessible to students who just needed to be able to count.

And I think that's actually quite a perfect example of how the same problem context uh can be meaningful and viable for students at different levels, not just a problem that they can engage in, but that they can get mathematical value from it.

Quite often when I speak to teachers, they worry that if, you know, teachers in one year level are running a problem, that means that they won't be able to run it with students the next year as they progress through the years. And I actually think it's a really nice opportunity to repeat a problem because students can then go a lot deeper with it and often by having had that long gap they're going to that bit more sophisticated in their thinking. So they might have new strategies that they can bring to the problem or new concepts that they understand that help them to see the problem in us. So I definitely advocate repetition also just want to share something that I've always found fascinating with a

common, I think not a common, but probably a difference that I've noticed between primary and secondary teachers, which kind of draws on the different strengths that those groups of teachers bring.

So we have primary and secondary teachers together in the same space quite deliberately sessions for math teacher circles and afterwards, primary teachers will say to me that was fantastic. I learned so much from the secondary teachers about where the maths can go. And secondary teachers will say to me that was amazing. I learned about all these new tools that I could use and ways of expressing the ideas that we were looking at from the primary teachers. So again, exactly the same problem. But each of those groups are so well versed in the context of primary and secondary that they're naturally, I believe there are strengths that come through in their practice.

LEANNE: I love that idea of doing that too, because as a trained secondary teacher, the first thing we say is “what were they learning in primary school? Why don't they know this and blame the primary teachers. Of course, once I've got into teacher education I've realized it's just a whole different world and the best way of dealing with it is get the primaries and secondaries together.

MICHAELA: Yeah,

I'm a big fan of diverse spaces. Primary and secondary teachers, new teachers and school leaders, you know, whatever sort of a mixed up group of backgrounds you can get and it's incredible the conversations that then happened and the insights people get from one another.

LEANNE: Absolutely. So can you talk to us about the stages of a problem solving lesson?

MICHAELA: Sure.

So these are there are three stages that I see exist in a problem solving lesson. These apply to a lot of them, whether they're games, real world problems and more abstract mathematical ones. Some won't fit into this model but a lot actually will.

The first stage is around launching the problem. The second one is exploring the problem and the third is concluding and I'll tell you a little bit more about each of them and kind of some things that you can keep in mind when you are going back to the classroom and running some problems with your students.

I've had the fortunate experience of working with some incredible people through math teacher circles and getting to see them in action people like Dan Finkel from math for love, incredibly experienced teachers like Jacquie Lee or Sam Hellessey who I mentioned before, mathematicians like Norman Do and so these sorts of insights that I share, I really glean from them and others.

So if we look at the launch. The launch is where you introduce the problem and you introduce it in a really brief amount of time, like less than five minutes. It doesn't need to have bells and whistles. I do remember trying to launch a lesson and just do a lot more than it needed. And now the things that I've noticed is a launch can be all about presenting a mystery to students or sharing with them an example and non example and inviting students to think about what they notice and what they wonder. Or you might run a demonstration game or show students how to use a tool. So really the purpose of the launch is to enable students to understand the minimum information they need in order to get started with a problem and to start to get interested in it.

This is then followed by the explore stage where students have time to dig deep into the problem or to play the game to really get their hands dirty. And so, you know, if we go back to the question that we're looking before around, you know, you've got these four triangles from a square and how many different shapes can you make using those four triangles? So students will be exploring this problem and you as a teacher might be wandering around the room with some prompting questions ready to go.

You start with the students who are struggling to get started. And it might be about, you know, re explaining the question to them or getting them to articulate their thinking. You might also have some extra tools and resources in your back pocket. Sometimes this will be like grid paper or physical manipulative, anything that might help students to go deeper and further and just more questions, questions, questions, questions. It's all about helping students to articulate and push their thinking and you know, think about how is what they're doing relevant to the problem at hand.

Now, these two stages, you know, often students might kind of get lost in it and not even realize kind of what the implications are, what they've learned. But the concluding stage of the problem is such a pivotal stage for drawing it all together. And often this is where most of the learning happens. So it's where students might observe patterns where they might make connections, understand the point of what they're doing or even make sense really of the strategies and the findings that they've got into.

So the conclusion, it’s not just about is this the answer. Great, we’re done. But sharing the strategies and getting students to explain how the strategies work and why they work, seeing what the conjectures are. You know, conjecture might be that there are only six possible shapes that we can make out of four triangles? Alright, well anyone that found 1/7 that we can use to prove that wrong? How do we know when we found all of the possible shapes using those four triangles and there might be new questions that also kind of come to the forefront in this concludes stage. So for example if instead of starting with a square, we started with a hexagon and broke it up into equal sized triangles and we use those triangles to make any possible shapes together. Wonder what different shapes we could make. And it's kind of then showing students as well that once a problem is done, we don't wipe our hands and walk off. But it's actually then opening the door for new and fascinating questions that are worth exploring.

LEANNE: Before I let you go, there is one question that I know that I'm going to get from teachers. So I'm going to ask you now, where do you get your problems?

MICHAELA: That is an excellent question. Let me see how best I can summarize this. I look for sources of inspiration around the place.

So I'm on twitter and you can follow math teacher circles that math circles Oz or you can look for math teacher circles on Facebook as well and you'll see lots of juicy problems and I suppose over time I found books and other people online who have really interesting problems but also importantly, often you can tweak certain context, maybe it's a problem that you already like or it's a problem that could be more interesting and you just tweak some of the details and it makes it into something really juicy and fun to dive into. I think often just your typical resource of what you've already got at school. Like your textbook can be an awesome starting point. Find a few problems, maybe reduce, remove some parameters or start with answer and flip it around so it's about finding the starting point. The more you practice and play around with these, the easier it becomes I think come up with problems. But also I'm a believer in

not reinventing the wheel. So find some sources of inspiration those places and people who share problems that kind of resonate with you and use those.

LEANNE: Sounds great. We'll put a list of sources that we use at AMSI on the show notes.

Well Michaela thank you so much for being our guest today. It's been an absolute joy for me to have a chat and getting the enormous knowledge and expertise you have and this is just a small part of what you know, and I'd really love you to come back one day.

How can people contact you so that they can find out about the teachers circles and any of the work that you've been doing.

MICHAELA: Sure.

So if you'd like to find out more about maths teacher circles, you can head over to our website So I've put together the URL. For this podcast. Mathsteachercircles.org/amsi And I'll share it with you Leanne and maybe you can make that available for everyone.

You can search for us on Twitter or Facebook like I mentioned or get in contact with me via email Michaela@mathscircles.com.au If you love talking maths, please do get in touch if you have questions or ideas you want to share and you know, we've got a full program coming up next year of Maths Teacher Circles, I'm really excited about it. We have a fun, fantastic range of themes and presenters.

So you can join us with circles membership, which actually gets you access to a full year of professional learning. It's up to about 15 hours of it and you know, you get to join in with this really thoughtful teacher community. So anyway, if you are interested in it sounds like your cup of tea, head on over to the website or get in touch with me.

LEANNE: That sounds absolutely fantastic.

Thank you for that and thank you again for being here with us.

MICHAELA: Thanks Leanne,

LEANNE: it's been a pleasure. You've been listening to Maths talk by schools for our show notes and information on this podcast and a lot more head to our schools Teacher support web page at calculate.org.au If you have any questions, comments or suggestions for other podcasts, please drop us a line at MathsTalk @AMSI.org.au. Hit us up on Twitter or Facebook. Thanks for listening, and we'll see you next time.