

The NCETM Podcast Episode 57

Using number lines in Key Stage 1

Hello and welcome to the NCETM podcast. My name is Steve McCormack [SM] from the NCETM's Communications Team, and with me today, I have my colleague, Debbie Morgan [DM], who's the Director for Primary Mathematics at the NCETM. We're having this conversation in the middle of February 2022, just after or just before half term, according to where you are in the country. Today, we're going to talk about number lines and suggest a few ways you might like to use them in Years 1 and 2. Now you might be thinking this is a podcast. How's that going to work when I can't see what they're talking about? Well, that's a fair point, but we're going to give it a go. Using our powers of description and your powers of imagination, which is, after all, what we ask children to do quite a lot. If you're not driving or otherwise engaged with your hands and eyes, you might like to press pause. Get some paper, a pencil and a ruler to draw things out as we talk about them. But if you are driving or doing something, I hope it will work almost as well if you can't do that, so let's get going. First, Debbie, what's the objective? We're going to talk about a specific type of use of number lines rather than what teachers maybe have been using quite a lot in the past. What's the sort of objective in your mind of this sort that what we're going to talk about? What's the objective of using these with?

DM: So my objective is to use the number line not as a calculating tool that very often that's happened in the past where we've used the number line to add two numbers together, starting with the first one and then bridge through 10. So 26 - for example, I add 4 to get me to 30 and then two more gets me to 32. So we're not going to use it as a tool to do maths with, but we're going to use it as a tool to understand relationships within mathematics. And I particularly draw attention to the Non-statutory Guidance that was published by the DfE in in the summer of 2020. There's a particular strand within the ready-to-progress criteria - you'll notice that in Year 1 it says reason about the location of numbers to 20. In Year 2 it says reason about the location of two-digit numbers. Year 3 reason about the location of three-digit numbers. You've got the idea. So that word reason is really important and we're going to use number lines so that we can reason about numbers and their location within that linear number system.

SM: OK, well, let's get started. We're going to talk in the next 10 or 15 minutes about five number lines, and the first one I think you want to talk about is just a line with one at one end and 10 at the other, and nothing in between. Is that right?

DM: That's right, yes. So let's just look at this line now. Children can already count to 10, and you can ask them, what are the numbers go between 0 and 10, and they will tell you quite confidently in Year 1 that we can have 1, 2, 3, 4, 5, 6, 7, 8, 9. OK, brilliant. Now can you draw them on your line? What I will predict and you might want to draw them now. In fact, if you draw your line number line zero to 10, can you put those other numbers on your number line?

SM: So you're suggesting that a teacher just ask the children? OK? Put the numbers 1 to 9 on this.

DM: Yeah, exactly. And what you will probably find is that they'll bunch most of them up to the left-hand side. They'll start quite confidently, drawing 1, 2, 3, 4, 5, 6. They get to about 7 and they're still not halfway along the line. For the last few they will spread out 8 to 9 and now I've got to 10, so they won't be equally spaced. That's because they haven't fully developed those spatial reasoning skills and fully appreciate that numbers on a number line need to be equally spaced. So we are drawing attention to it. I wonder where you started when you drew, when you wrote your numbers 1 to 9 along

your zero to 10 number line. Did you start at 1? Or did you maybe start at 5, the midpoint or that number line? Because once you've got five in place, then we've got a benchmark for a place in the other number lines and having a better chance of getting them more equally spaced. So that's the first thing we need to draw attention to. And teach children the midpoint, of course. If they've got a strip of paper, then they can find the midpoint by folding it in half. You might want to use two fingers. If you just imagine I've got my two index fingers pointing at vertex. Quickly - and they're fairly close together at the moment - but I'm just going to spread them apart and I'm going to stop there. So I've got a gap between them. Can the child next to me put their finger where they think that midpoint? So plenty of practice at looking for that midpoint being outside on the playground and just drawing lines of different lengths. Can they place a teddy on that midpoint? So getting that benchmark initially of that midpoint in relation to thinking where numbers fit within that number line of zero to 10.

SM: So presumably I'm imagining a class of children in Year 1. The teachers asked them to do this. Looking around the room, there will be all sorts of different ways in which the children have put 1 to 9, and that, I presume, would be an opportunity for the teacher to open up a discussion and start asking questions, and just get the children talking about what they've done.

DM: Exactly. Yes, because what you want to draw their attention to, of course, is that those numbers should have been equally spaced within that. And they're not. And how can we get our numbers equally spaced and that's why. And you introduce the idea of the midpoint, what number comes in the middle, and then you're developing their spatial language by talking about 'in the middle'. Halfway along the midpoint and looking at this spatial arrangement of where the numbers fit in relation to each other.

SM: OK, so in that exercise the children would have found out a lot themselves, and the teacher would have found out a lot about the children. So the next one we're going to talk about (probably on a different day in teaching) is again, aligned nought at one end, 10 at the other, but all of the numbers 1 to 9 put in the right places by the teacher, so that's what the children would be looking at, and what might the teacher do with that?

DM: OK, first of all, can we identify the midpoint? Ah, the midpoint is five, of course it is: that's in the middle of my line, I already know that. And then playing some games such as true or false, using the inequality symbols. So 7 is greater than 8, true or false? Well, no, that's not true, because 8 is larger than 7. But justify their explanations - children's explanations are really important - so can you prove that to me using your number line, or that the number 8 comes after? Again, we're back to that spatial language comes after the number 7, so therefore 8 is greater than 7, and 7 is not greater than eight. So they're justifying it, but also we're drawing attention to where the numbers fit on the number line and that the larger numbers come to the right. And the smaller numbers come to the left.

SM: And is there a sort of another game that a teacher might play? 'I'm thinking of a number...', that sort of thing.

DM: Yes, exactly. So I'm thinking of a number and my number is greater than 5 but less than 7. Of course the answer is 6, there's only one answer to that, but then you might open it out a little bit more. So I'm thinking of a number. My number is less than five. But greater than two. So again my orientation is directed to a particular part of the number line or and there's two possibilities here. Can we justify both of those, and of course to nail it precisely. Then we need some more information. So again what I mentioned at the beginning, that verbal reasoning as to where the numbers fit within the number system is being developed for the children.

SM: OK, let's move on to the third line. Again, probably a different time, different week. Maybe we're back to the empty number line. We've still got nought to the left, 10 at the end, both marked, but

nothing in between. All based on what the teacher might have done in previous weeks. How might that conversation start?

DM: Again, we will be asking them to place our numbers 1 to 9 on our number line. First of all, telling us what those numbers are. Well, we're very confident with those numbers. We know where those numbers go, but just maybe prompting them to think, 'hmm, are you going to start at one or where might be a better place?'. Of course, they know midpoints by now, so we're drawing on that so they can place that 5 as the midpoint on there. And they've been thinking a lot about where the other numbers fit. So where do the numbers go? To the left of five. What are those numbers? Well, I'd need 1, 2, 3 and 4 there. So they've got a better sense of being able to space them out evenly and see where those numbers fit in the number system.

SM: And presumably I'm imagining again a class of Year 1 or Year 2 children doing this, and a teacher wandering around looking. Should the teacher be too, too strict about 'Oh no, that gap there, that interval there is not exactly the same as that interval there'?

DM: No, it's not a measuring point: the real point of this is that children can reason where numbers sit in relation to each other. You might want them to compare their number line with their friend's number line, and they might draw out the fact that actually this number line is slightly better because the number lines are more equally spaced, and so we're drawing out that point about the equal spacing.

SM: OK, I'm going to bring out a point here which I think is important. When children, and indeed teachers, put marks on number lines, you do sometimes see children putting the actual number, the digit, in between the marks, don't you, rather than absolutely on top of the mark, and that's something teachers need to watch, isn't it?

DM: It is, because actually children have already had experience of number tracks where we do place the number in between a space on another track. If you can imagine carpet tiles with numbers, a very common resource being used in Reception, we line those up, and the number is bang in the middle of each tile. A number line is different, in that we are counting intervals. So the position of where that number sits on the number line, just underneath or above the mark that's made - that's the only point that represents 2 on that number line. Because what's going to come later, is that even between 1 and 2 there are other numbers, and so we're going to add other numbers to the number line later on as we progress, whereas on the carpet tile that 2 sits in the middle because the whole of that tile represents the number two, and we put it with 1. We've got that cardinal sense of the whole of that area, that it represents 2 - we've got 1, 2, we've got 2 tiles.

SM: OK. We're moving on to our fourth example now and that's I think going to enable the children to do a bit of practical work. So we're imagining again a number line between 0 and 10, but we're going to add measures, we're going to say nought to 10 centimetres on a piece of paper or a piece of card. So what's the aim of introducing measure now to a class?

DM: Of course, measures operates within our linear number system. So a ruler is in essence a number line. But even before we introduce the ruler, we can just introduce a strip of paper with zero to 10 and make sure that that strip of paper is actually 10 centimetres, so children have got a realistic context, and then armed with their strip of 10 centimetres, can they find objects that are shorter than 10 centimetres, and then can they find objects that are longer than 10 centimetres? Of course, what we need to remind them to do is to line up their strip of paper so that one end lies at the end of the object. So we're developing that accuracy that when we do use a ruler we're developing that skill, and then moving on - can we find an object which is longer than five centimetres, but shorter than 10 centimetres? So we're getting a bit more precise about what those do and we might even start to estimate. Even though we haven't got other numbers on our number line, we might start to estimate

what we think is about 7 centimetres because it's between 5 and 10. But it's not too close to 10 or it's not too close to 5, so that kind of reasoning. Again, we're back to that reasoning about where these numbers fit in the linear number system.

SM: And the 5-centimetre point brings back the midpoint, the whole midpoint concept, doesn't it, which runs through the whole.

DM: Yes, precisely. So we mark our 5 centimetres that the children write their 5 centimetres on their line, so they can see that and appreciate that's the midpoint. So we're building on that midpoint again.

SM: And the reasoning element brings out the importance of language children talking about the maths, using the right words, explaining what is and what isn't happening.

DM: Yes, exactly. And our work that we we've done on the zero to 10 number line where we were justifying whether 7 is greater than 8 or the 'guess my number' game all play into this, and build on children's reasoning and making sense of how numbers fit into that linear number system.

SM: OK, right. The last line, we're going to talk about. It might be the same length on you listening to us drawing it at home, starting at nought. It might be the same length as the one that we've had up to now, with 10 at the other end, but we're going to put 20 at the other end. And so how might that help a teacher move a class on, Debbie?

DM: Actually start your step before that, Steve. I'm going to suggest that we line up two number lines: one zero to 10, and one the same length, but 10 to 20. So we're placing each one horizontally with one above the other lined up, and then asking what do you notice? Well, of course the digits zero to 9 are mirrored on there. So on our zero to 10 we've got 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and on our 10 to 20, we've got 10. We've got 10 and 1, 10 and two which we call 12, 10 and 3, which we call 13. So we can see that relationship between the numbers that come after 10 and the numbers that come before 10, that there's just a repetition in our pattern of them. And what we can do then, having recognised that relationship, we can find the midpoints so we can see the midpoint between 0 and 10 is 5. We're very good at that. But we can transfer that knowledge to where the midpoint between 10 and 20. So we've now lined up our two number lines into a whole number line overlapping the 10s. So we've now got zero to 20 number lines. So we can see our midpoint is now 10 on there, and in a sense it is the midpoint in the same position as it was on our zero to 10 number lines when we were working with those. The answer is yes and no - relatively, the midpoint is the same. It's always in the middle between our two endpoints. But of course it's a different number, because this now represents a zero to 20 number line. And then moving on, between that, can we mark the midpoint between 0 and 10? Yes, we can. We know that's five. We're very confident with that. But can you transfer that knowledge to the midpoint between 10 and 20? Yes, I can do that - it's 15, of course. It's 15 - that 5 is coming again. That 10 and 5, 15 - those ten-and-a-bit numbers, so tricky teen numbers are making sense to me and how they fit into the linear number system, and how that's mirrored. Throughout the whole of our number system into infinity, it's quite a wow moment of making connections and making sense of our linear number system.

SM: OK, that's great. Thank you. Those are our five examples. One question has just popped into my head: all of the number lines we've been talking about so far have had a fixed end at the left, a fixed end on the right. When and how might teachers start just acknowledging the fact that there are numbers way over to the left? And there are also numbers way over to the right - when might that happen? Not yet in Year 1 and 2?

DM: Well, I think it depends on what our focus is. Our focus has very much been about where numbers sit in relation to each other and particularly drawing out that benchmark of the midpoint. So

to have a middle point, we need to relate to the endpoints to identify that middle point. But of course number lines are infinite, and if we want to understand the infinity of the number system - which of course we do, another awe-inspiring moment I'm sure - then actually we can just extend our number line, maybe extend the right-hand side. First of all, could we have some more numbers if we extended our number line? Of course we can - the children tell you. If we've got a zero to 20 number line and we extend it a little, the bit what might come next? 21 of course - they'll tell you! And so we can extend into infinity, and when we want to introduce negative numbers, of course we can extend our number line the other way. Now children already have a good sense of whole numbers on number lines, and therefore that the next number is 1 more than the previous number, and so therefore going back one space from zero is going to be 1 less, isn't it? That's how our linear number system works. Of course it's going to be 1 less. What do you think we could call it? Well, you know, children might come up with all sorts of ideas, and they might virtually get there and be able to tell you that actually, it's one less than 0. It's zero take away one, ending up with -1, 1 less than 0 is negative. What do we think 2 less than 0 is? They can tell you because they've been reasoning and they've been making sense of this all along. So suddenly negative numbers begin to make sense to them. They're using their reasoning and their sense-making within the context of this representation of the number line.

SM: OK, thanks very much. So we've looked at those five examples imagining this happening in Years 1 and 2: where in general terms is this going for the rest of primary school?

DM: Of course the linear number system continues with numbers. So numbers in between zero and one. And so we can either think of decimal numbers, probably starting with tenths within that, and again they mirror. Looking at a zero to 10 number line and looking at a zero to 1 number line, we can see that mirroring of the 1, 2, 3, 4, 5, 6, 7, 8, 9. Except this time we've got 1 tenth, 2 tenths, three tenths, 4 tenths, etc. on that number line. Children typically find decimals really tricky, but seeing them as a continuation of our linear number system and seeing them in a representation that they're already familiar with, and they already really know how this works, and they can reason about numbers on there, then actually they can use that in the context of fractions. Of course, you know, halfway between zero and 1. What do we call that? We call it half, don't we? Because it's halfway along. We've already been using that language up till now. So they are particularly important for building other numbers and making sense of those other numbers. So that actually we can work with those other numbers and relate with them.

SM: Great. Thank you. And if there's a secondary teacher here or a Year 6 teacher who knows a bit about Key Stage 3 maths listening, they will know that number lines exist right up through secondary school. So what we're going to do in another NCETM podcast quite soon, I hope, is get a secondary teacher, perhaps a secondary colleague from the NCETM to talk about where number lines go in secondary schools. But for now Debbie, thanks very much for giving us your time, and thank you to you at home listening to this, whether or not you've been joining us in drawing things on bits of paper, or you've just been listening and using your imagination, we hope you've found that useful, and given you some ideas of how you might introduce, augment or just expand your use of number lines with your classes at primary school. So thanks for listening. If you found that useful, please let your colleagues know. You can subscribe to the NCETM podcasts with your podcast provider to make sure you don't miss the next one when it comes out, because there will be another one and we will be back with another NCETM podcast very soon. Thanks for listening!