The NCETM Podcast Episode 74

Using number lines in Key Stage 2

Hello and welcome to the NCETM podcast. I'm Julia Thomson [JT], Communications Manager at the NCETM, and I'm in Manchester today to talk to some teaching colleagues who are participating in the Years 5- 8 Continuity Programme with Turing NW Maths Hub.

Today, we're going to be talking about using number lines in Key Stage 2. We've already spoken to NCETM Director for Primary, Debbie Morgan, about using number lines in Key Stage 1, and Assistant Director for Secondary, Becky Donaldson, about how number lines can be used in secondary. So we're keen today to explore how number lines can be used in Key Stage 2.

It is the second part of the summer term, so you may hear some air traffic overhead throughout our conversation.

So just to begin, can you tell our listeners a little bit about who you are, your background and how you came to be involved in this project? We'll start with you, Julia.

Julia Morgans [JM]: Yes, I'm Julia Morgans. I'm the Maths Hub Lead for Turing NW, which is based at Ashton on Mersey School in Sale, Trafford, and I've been doing the role for two years now. I'm a qualified primary teacher and I qualified in 1989. I've taught in Early Years and both Key Stages and I started working for Turing NW as a Work Group Lead for Mastery Readiness, which was set up in the north westas a pilot programme in 2018.

JT: Brilliant. And Jenny?

Jenny Ruddock [JR]: Hi, I'm Jenny Ruddock. I'm the deputy here at Corrie Primary School, which is a two-form entry school in Denton in Manchester. I have been teaching for 19 years and worked across all key stages from EYFS to Year 6. I've been working for the Maths Hub for quite a long time now, but more specifically this year I'm the Work Group Lead for the [Years] 5-8 Continuity Programme.

JT: Excellent. And Jordanna?

Jordanna Worrall [JW]: I'm Jordanna Worrall and I'm a senior lead for curriculum at Denton Community College. I've been teaching for nine years and I've been head of maths at Denton Community College Secondary School for five years, and I've taught all groups throughout secondary school.

JT: Excellent. Thank you. So each year the Continuity programme has a different focus, and this year all of Turing NW Maths Hub's Continuity Work Groups focused on the number line: why the number line?

JM: Well, it was a particularly interesting area because the new DfE maths guidance for primary schools that was published in 2020 highlighted the importance of children being able to reason about the location of any number in the linear number system, and the Ready-to-Progress criteria states that this is an outcome from Year 1 right the way through to Year 2. And then the guidance also gives future applications - the ability to be able to reason and understand the number system in Key Stage 3, where students might use linear and quadratic graphs, for example, and it's really important that they have that opportunity.

JT: So what prompted your Maths Hub to focus particularly on the linear number system?

JM: Well, our attention was drawn to an action research project that was carried out by Ruth Trundley and Stephanie Burke from Jurassic Maths Hub in 2019 called Understanding Structured Number Lines, and they highlighted that many teachers use number lines and children from across the primary age range didn't understand the structure of a number line. As Debbie Morgan mentioned in her podcast, they were using it for counting rather than to understand the structure of the number system. So we decided that this would be a

really great way to find commonality within primary and secondary. So before our meeting of our local leaders of maths education, we asked them to go into their classrooms and do an assessment with their learners based on the assessments that they've done in the action research. It was a diagnostic tool to find out what the secondary colleagues found out about what their children knew about number lines.

And then we were also aware that number lines in classrooms are, again, as Becky said in her podcast, they're there as displays, they can be there on desks and more often than not, they're horizontal. So we think it's really important that our learners see it and interpret number lines for a purpose: why are we doing it? What's the point of it? So we would encourage all our teachers to consider all the different contexts that they use and the real-life situations that children might see numbers that are in a line. For example, Reception and nursery children will see vertical height charts, and they might see thermometers or even in a circle or on measuring scales.

JT: I was quite surprised to learn how many different ways children might see a number line. They might see it as a ruler, they might see it as a scale, they might see it, as you say, in a circular kind of orientation. So I think some teachers might think that it's just this static kind of line.

JM: And horizontal - and then we should show them vertically. The other thing that I think is really important, is one of the areas that we find difficult to teach in primary is the time, but actually if you take the time out and show it as a linear thing, a number line starting from 12:00 and you show it as a line and then join it up as a circle, that's been another really powerful way of helping children to understand our clock system. So it is interesting.

JT: I'm sure there'll be quite a lot of teachers, probably both in primary and secondary thinking we might try that!

So Jenny, you're Work Group Lead for the programme, but you're also a primary teacher, so you'll be familiar with the number line being used in Key Stage 1. Why were you keen to explore its uses in Key Stage 2?

JR: As children don't really have the knowledge or embedded use of number lines in Key Stage 2 to build on, they don't tend to choose them as a tool or a visual representation themselves, and quite commonly they're also presented with them rather than children being exposed to drawing them themselves.

And again, like Julia says, we identified lots of number line uses in cross-mathematical topics.

Children just don't have that depth of understanding of the structure to use in the number system: they are applicable to so many situations, and if teachers could use them as a really good model, then children can put that visual representation to the topic that they're being taught – ratio, coordinates, graphs – in cross-curricular teaching.

It doesn't just have to be a counting tool, which it invariably is, but that said, children in Key Stage 2 and 3 just don't use number lines. They don't choose to use them as a tool.

So as a Work Group Lead for example, I used a diagnostic assessment - quite simply, choose some children in your class and can they draw a number line from 1 to 100 with intervals of 10, and do they know where the midpoint is? Or draw a number line from 50 to 70 and show the midpoint? As we will find out from Jordanna as well, the outcome was really fascinating.

They thought 'I could do this' and even some of the Year 5 and 6s thought this'll be easy and it's staggering: the evidence was that they presumed children can draw their own lines when actually they can't – well, a vast majority couldn't.

Or they found parts of it tricky, trying to calculate the intervals or where the midpoint is, what is a midpoint. So there's lots of issues surrounding that simple concept that we all take for granted. And it made teachers very much aware of thinking very clearly when presenting tasks to children. For example, I'll just draw a graph with intervals of 10 - how do you do that if you can't draw a simple number line with intervals? So we started there, and it made us all research and think more deeply about using a number line as a visual representation in our own classes.

JT: Excellent. So Jordanna, what were your thoughts when you observed your students engaging with the diagnostic task?

JW: I took the diagnostic task and asked five different Year 8 students to draw a number line from 1 to 100 and label the multiples of 10, and what was really interesting was that students started from the beginning and labelled on 10/20/30 with no acknowledgement for where they were placed.

They knew they were counting up in 10s, but they crammed together 10/20/30 got to 70, realised there was a huge gap between 70 and 100 and then put 80 and 90 in. Now I was really shocked that they were Year 8 students, and that really led me to reflect on it - we assume they come to us in Key Stage 3 being able to do that.

We'll say to students, when we're doing graphs, draw a set of axes. But a set of axes relies on them knowing that a number line is equal width, and when you go up to GCSE histograms, they need to be able to do axes with equal width.

I think I was just so shocked that we're assuming this knowledge that they don't have, and I know Debbie Morgan mentions in her podcast about the lack of understanding about equal widths, but actually this really highlighted the importance of it at Key Stage 2 because at Key Stage 3, that understanding still isn't there, so it was a really, really useful tool, and really started us on the journey of how we can use number lines.

JT: I was just thinking when you were explaining what had happened, reflecting back to Debbie Morgan's podcast where she talks about doing a lot of work about just that, developing that spatial awareness of where the intervals will be, where the numbers will be, and it strikes me that if you don't teach that explicitly, if you just assume that children are going to absorb that understanding by osmosis, then you're going to get to a stage in Key Stage 3 where you've got a bit of a problem.

And another thing you mentioned there is how much of secondary maths relies on being able to draw lines and draw intervals and judge where the intervals are and what the numbers are. So this is something that's quite important to get right.

A key aspect of the Years 5-8 Continuity programme is collaboration between secondary and primary colleagues. So Jordanna, Corrie Primary is one of your feeder schools. Have your secondary colleagues been into it to work with the primary teachers? What's that been like for them?

JW: I had the opportunity to observe Year 5 and Year 6 as part of this project on number lines, and the primary colleagues came to Denton Community College to observe me teaching Year 8, and from what I got observing Years 5 and 6, I said I absolutely have to share this with my colleagues from my secondary school.

They have come into Corrie and observed Years 5 and 6, and what was really powerful was that in one particular lesson, a student - they weren't directed to use a bar model representation by the teacher - but they saw a problem, and just drew a bar model.

What I think was so powerful to see was how natural it can be for students when they are shown different representations a lot and it becomes routine. What they found powerful was that without any direction at all, a student just drew a representation. And I think that's what this 5-8 Continuity group provides, it's about secondary teachers actually seeing what primary schools are doing. And then we can continue that.

JT: Excellent. So Jenny, was there anything you learned about using number lines from a Key Stage 3 perspective, in terms of what you can do in Key Stage 2 to prepare children for Key Stage 3 maths?

JR: We just made the decision again, as a school, what we're hoping to deliver today is for teachers to be using accurate vocabulary, to be using number lines explicitly when delivering the maths lessons, to be reinforced in different representations, different orientations as well. Like Julia said, vertically, circular, whichever way, to expose them to the use of a number line. Drawing arrows on the ends of number lines as well - we were talking about that because it shows the infinity of numbers and it's just a section, like a snapshot of a section of a number line.

Also, making reference to number lines when teaching graphs, coordinates, scales, those kind of things, but more importantly for children to draw their own because they need that practice to be able to do that, especially at Key Stage 2, because quite often especially with the use of textbooks or computers or because of workload, teachers just give the children the number lines to place an arrow on or a specific number, whereas children aren't getting that exposure to being able to draw a number line and break it up into certain accurate intervals - they just don't have that skill, so it's very important that they do that themselves.

JT: I have to say, as a primary teacher myself, I can hold my hand up and say that on occasion I've given them the graph and told them to complete it, because the thought of asking the children to draw a graph, well, you just know you would have to spend so many lessons doing it.

But I think what we can see is that it's a vital, essential skill that we're giving them and it's worth taking the time to actually do.

JR: Yes, most definitely.

JT: So, as in previous podcasts we've produced on the number line, today we're going to be looking at some ways teachers can use them in their Key Stage 2 classrooms.

We'll post drawings of the number lines described, in the show notes, but if you are driving or listening on a walk, or if, like me, you like to listen to your podcasts while you're cooking, we'll try to describe them as clearly as possible so you can use your powers of visualisation and follow along.

So, Jordanna, are you going to be taking us through those ideas? So hopefully these might also be relevant to secondary colleagues as well.

What's your first number line?

JW: The first number line we've used is to help with rounding. Students were given a number line with arrows at the end like Jenny described, because we want them to see that the number line doesn't stop. It was a number line with arrows at the end with 40 and 50 placed on, and no other intervals and no other numbers.

And we asked students to decide which number 42 is closer to. Is it closer to 40 or closer to 50? This led us on to rounding to multiples of 10. But what was really interesting was that the students were really keen to use the midpoint, they felt really confident comparing the number we were giving them to where the midpoint was. So they were saying 42 is closer to 40 than 50 because it's below the midpoint and that language was really helping them to articulate what multiple of ten 42 was closer to, and that led on nicely to rounding to the nearest hundred and the nearest thousand.

The second topic we've looked at, and this was in the Year 5 classroom, was students focusing on finding fractions of an hour.

So in the first part of the lesson, the children needed to work out what fraction of an hour a child spent doing their homework. The children had a number line with no numbers on at all. We had to discuss what the whole number line would represent, so this created great discussion about how many minutes in an hour, what should we represent an hour as on the number line, and as a class we decided to start at zero and end at 60.

They then had another number line underneath that was the same size but split into four sections, and this created a discussion about the number of minutes in a quarter of an hour.

As I said before about the midpoint, they were really keen to show that, well, the midpoint is 30 minutes, that's half an hour, so 15 minutes is a quarter of an hour. I think the number line was really powerful for them to see the size of quarter of an hour in relation to a full hour and the number line really did that. Directly beneath that number line students were given another number line that was split into 12, and then they used their knowledge of equivalent fractions to show that it was 5 minutes and yet again the number line really showed the size of a twelfth of an hour in comparison to a quarter of an hour and a third of an hour.

The students were then able to use these number lines to solve problems which required them to add parts of an hour together.

So the problem was, a student spent a twelfth of an hour on his maths homework and a third of an hour on his English homework - how much time did he spend altogether? But I think the number line gave them a really strong visual tool of what numbers to add together and the sizes of the numbers which worked great. The number line created so much discussion about finding the midpoint first, every single time, and it was a really useful strategy.

This can also be extended to represent mixed numbers, mixed-number fractions greater than one, and whether it's greater than an hour or part of an hour. It goes back to what Jenny just said about the number line doesn't stop. So if this part of the number line represents an hour, if we make that longer, if we make it twice the size, it's giving students that flexibility – if the number's double the size, the number line might be double the length.

The third topic we've looked at with students is ratio and this was introducing equivalent ratio to a Year 6 class. In this lesson we used double number lines, we used them to support the introduction of equivalent ratio. So in the very first question, students needed to work out the ratio of stars to suns on a T-shirt. They were shown a picture where the ratio was one to three, and they were then given a number line that was horizontal with six equal parts, and it was numbered 1 to 6. The number line directly below was split into 6, but the only number labelled was 3, which was directly below 1.

So if you can just imagine that it was two number lines and it showed that the ratio was 1:3 because it had the 3 directly below the 1. There were no other numbers labelled on the bottom number line, and the children were required to fill the other numbers in.

So they had to fill in that 6 went below 2, 9 went below 3, 12 went below 4. What was really interesting here when we watched the students in the lesson, is that some students went up the number line in multiples of three, so they quickly spotted that it was 3, 6, 9, 12. But other students spotted that the numbers on the bottom number line were three times bigger than the numbers on the top line.

And that really highlights the multiplicative relationships between the numbers and the different methods you could use.

Another double number line we used in that lesson had on the ratio labelled 4:8 and it had 4 on the top and 8 on the bottom.

On the top number line, we labelled multiples of two. Now what the students could see straight away from the number line, was that we only had one number labelled on the bottom one, but they could see it was double, so that the number lines created such a visual tool to show the ratio 1:2, because immediately students were saying 'the numbers on the bottom number line are double the numbers on the top', and that was really powerful to see. The questions then increased in difficulty, and the students went on to use the number lines to assist in their learning.

So they were working backwards to find the ratio 1:2 and then, as an extension, can you give me a ratio that's equivalent to 1:2? That wouldn't be on the number line, but having that number line as a starting point to see the relationship between the number - that was really powerful.

What some students did was to fill in numbers directly to the left and the right of the number they'd been given, and I think that goes back to their knowledge of numbers equally spaced on a number line. So if I've got the number 2 and it's going up in multiples of two, I've got zero on one side and 4 on the other, whereas other students were able to just see the relationships quicker and move to bigger numbers, but I think the number line really helped with that journey.

JT: Excellent. That's fantastic. So what strikes you straight away is the sheer breadth of uses that you can make, and also I think the time one in particular, that's so powerful because children really struggle with time, and I think teachers struggle to teach time. As an adult when you just get something, it's really difficult to explain to a child.

JM: And it's very abstract, isn't it? What you're describing to the children seeing the minutes on a line, but actually that abstraction because it's in a circle sometimes makes it harder, so introducing the clock as a line as well as the circle is really interesting.

JW: Yeah, and if you carry on the journey of time, if I'm doing speed/distance/time with the GCSE class, a lot of them fall into the trap of, if they get the time as 0.25 hours they write, that's 25 minutes. But I think going back to if they start their journey with time by seeing it on a number line, seeing it as quarter of an hour, that would help their understanding.

JT: Well, that brings our conversation today to a close. I really hope you found our discussion as interesting as I did.

And if you'd like to know more about the Years 5-8 Continuity Programme, you can contact your local Maths Hub to find out how you can get involved.

Links to all of the resources and research mentioned by Julia and how to find your local Maths Hub will be posted in the show notes for this podcast on the NCETM website.

Thank you so much to Julia, Jenny and Jordanna for taking the time to talk to me today and thank you for listening.

If you've enjoyed this podcast, please do share it with colleagues. We'll be back with another episode soon, so make sure you follow us or subscribe wherever you get your podcasts to make sure you never miss an episode.