How would you approach the task, “Take a box of Smarties and draw a pie chart to represent the make-up of the box by colour?” I think if this task was given to most of the classes I teach, they would first group the Smarties by colour, then count up how many there are of each colour. Next they might find the total number of colours, represent each colour as a fraction and find this as a fraction of 360°. Then draw a circle using a compass and finally use a protractor to measure the requisite angles.

What if I was to say that you could not use a compass? Or a protractor. Or a calculator. Or numbers. I would, however, be happy with an approximation to a circle but I would want to be convinced that the size of each slice of pie is as accurate as possible.

If you were at one of the sessions with Mike Ollerton and Helen Williams at the British Congress for Mathematics Education (BCME) 2014, you might recognise this. If not, and you want to ponder possible approaches then I suggest you stop reading now because all is revealed by the end of this account.

Last year, as a Newly Qualified Teacher (NQT), I had a low-attaining Year 7 class (set 5 out of 5). The topic we had reached on the curriculum was ‘Representations of data’ and I was advised by colleagues against covering construction of pie charts with the group because of all of the calculations involved. I remembered BCME 2014, so I introduced my class to the method I had learned there with some success. They all quite proudly produced a pie chart on a poster by the end of the lesson. I wondered what my response would be to the question, “Yes, but how will they answer an examination question on pie charts?” In all honesty, based on the skills they had at the end of that lesson they probably would not be successful. I had not had the time to build on and develop their skills in a formal setting, which I feel they would need to answer an examination question. What I am convinced they gained, however, was an awareness. An awareness of what a pie chart is; an elementary awareness of how one is constructed; an awareness that the sizes of the sectors (or ‘slices’) are directly linked to how many there are of each colour and an awareness that all the slices of the pie together represent all of the Smarties. They have also become comfortable with working with pie charts so, hopefully, next time they come across the topic and address it more formally they will do so with an open mind rather than negative preconceptions.

At the Association of Teachers of Mathematics (ATM) Conference this year, I spoke with Mike Ollerton to thank him for the idea of drawing pie charts in this way. It was an approach that enabled low-attaining year 7 students to access pie charts, something that I took great pride in being able to do. Drawing on this discussion and conversations with other conference attendees this year, I decided to use the smarties approach with my higher attaining year 7 class. My school has an intake with high attainment and therefore our top sets, even in year 7, have a well-developed body of mathematical knowledge. As they are confident mathematicians, I was a little unsure how they would take to the task or how quickly they would complete it but I decided it was worthwhile to develop their awareness of pie charts. Before my conversations at the ATM conference, I would have assumed that such an approach would suit only pupils at primary school or groups with low prior attainment like the year 7 group I had taught last year. So, I was concerned that a group with much higher attainment, who have explored pie charts previously, would find the work with smarties overly basic. To my surprise I had some of the most remarkable results.

Working in pairs, every pupil took the approach outlined at the start, grouping the counters by colour, then they calculated the totals for each colour and used this total to calculate the proportion of the whole. As I walked around the room, I saw notes written that included “33 total. 3 blue = 1/11” which, given the restriction of not being able to use calculators or protractors caused many to ask if they could “randomly lose three counters” to make 30, which would be much easier to work with. I said, “No this is not allowed”. The pupils thinking then developed. They began comparing the size of groups of colours, 4 red and 4 blue, meant those sectors needed to be the same size, whereas, 7 yellow meant it needed to be just less than the size of red and blue together.
Developing awareness of pie charts with a variety of attainment groups

The restriction I had placed on the pupils forced them to think about a pie chart in a different way, but they still did not know how to draw a sector of the correct size. They knew two of them had to be equal and a third sector had to be slightly smaller than those two combined, but there remains an infinite number of possibilities where that is true. Trial and improvement was attempted using a whiteboard, so I challenged them to think about how they could be convinced that the sectors are as close as they could get to the right size. Trial and improvement, I told them, would get them something that looked about right, but it isn’t convincing. Image 1 shows one attempt which was made by a pair using a form of trial and improvement combined with sight judgement.

Almost simultaneously four groups in different parts of the room decided to arrange the counters in a circle, in colour groups, around the circumference. I took a photograph of one example of this and displayed it on my whiteboard projector and asked pupils to discuss the image. The responses were fascinating, drawing out equivalences that I had not even noticed. My favourite among these was that “yellow + white = green = red + blue therefore green must be a third” followed by “yellow = white and yellow + white = green so yellow and white must be a sixth”. These two statements were not just powerful in themselves, but they were also presented with complete confidence and accepted as obvious by the class. Image 2 shows the image presented to the class. Sadly, upon looking again at the image I realise that green is not equal to red + blue, however, given none of us in the room noticed this at the time I don’t feel it detracts from the power of the observation. If we all believed red to be equal to 5, then the mathematical conclusions made were still just as striking!

One of the more remarkable moments for me came next. Half an hour into the one hour lesson, I handed out a worksheet on calculating angles in pie charts and drawing them on pre-made circles. I was about to launch into a discussion on how to fill in the table, a recap of using protractors and finding fractions of amounts to get the class started, but I did not get the chance. With enthusiasm the class started the worksheet without being asked. The class were not yet completely fluent and there was a buzz of chatter as they helped each other. They had a deepened awareness of, and a comfort in working with, pie charts, which meant that the last half hour of my lesson barely required any involvement from me at all.

At the end of the lesson I asked the group how many had learned about pie charts at primary school. Around three quarters of the pupils raised their hands. Some commented that they had forgotten “what to do” with them. However, by the end of this lesson all the pupils had calculated the angles from a frequency table and drawn at least three pie charts each. I did not explain the skills involved in drawing a pie chart at all during the lesson. This lesson showed me the value of working with students’ awarenesses rather than trying to get them to simply remember techniques and rules.

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