Nobody told **Mike Ollerton** he would never be able to do a three-ball juggle. So why, he asks, do we predict that some children will not be able to learn mathematics?

LEARNING TO JUGGLE OR JUGGLING TO LEARN?

About three years ago my eldest son went to stay with friends and whilst he was away he learnt to juggle. When I tried I was hopeless and I marvelled at how he had been able to learn this skill in just a few days. I tried and tried but only frustrated myself by my constant inability to achieve any modicum of success.

Two years ago I learnt to juggle. A sign on a shop in Nottingham read 'If you have 5 minutes to spare ask inside for a free juggling lesson'. In the event I think I learnt the hard way. I worked on the instructions that I was given but it took me two days to get anywhere, and I didn't feel very confident. I returned to the shop and on this occasion a different person worked on my technique. This second teacher provided me with two essential ideas to work on and it was some simple advice that made all the difference. What interests me now is the teaching method by which I can help others to become a three-ball juggler. In the past few weeks, whilst boring my friends by trying to give them juggling lessons, I feel I have achieved a clear understanding of what kinds of instructions are useful, by close analysis of the way in which I began to achieve success.

I have since given juggling instructions to interested students at my school and in doing so it occurred to me how learning to juggle had similarities with learning mathematics.

I offer the following analogies:

- choosing an easy starting point to simplify what looks like a difficult task;
- building up a confidence that is based upon 'I can do (if I want to)';
- persevering with learning and practising new skills.

Starting with just a one-ball juggle and throwing this ball in an arch across to the other hand feels to be an important confidence step in attempting a two-ball juggle. The two-ball juggle is an extension of the one-ball, with the second ball passing through and under the path of the first. This needs to be practised. The next step of getting the third ball in the air is one of having the confidence to put it in the air, but instead of trying to catch it just to let it fall to the ground. This shouldn't be seen as a mistake or as a failure, but as a step towards gaining confidence and competence. The other important piece of advise was that, for a three-ball juggle, you are only ever throwing one ball in the air at any time. Eventually,instead of just letting the third ball fall to the floor I was encouraged to try to catch it. Having practised this routine it becomes a case of sending the fourth ball (first ball again) into the air, and so on.

When I first wrote this I was concerned that my image of step-by-step learning would infer that the learning of mathematics is entirely hierarchical and that perceived 'higher' level skills could not be engaged with until simpler concepts were in place.

Walking with a friend in Wasdale in the Lake District the other weekend it occurred to me that there was another important principle at work in the juggling analogy. This is that working on the two-ball juggle provides a context and an incentive for practising and perfecting the one-ball juggle. Similarly when doing the three-ball juggle, the two-ball juggle is being practised, perfected and contextualised. In learning mathematics I believe that, for some students, it is through engaging with, for instance, concepts of measuring that a context is provided for working on counting skills. Likewise developing concepts of Pythagoras provides a context for learning about area, decimals, measuring, counting ... and vice versa.

If at any stage either the two-, the three- or the four-ball juggle can't be done then it is important that an earlier stage can be returned to. In order for the learner to be able to do this, the teacher needs to provide a simple starting point for the learner to return to and from which ideas can be developed and extended. The phrase that comes to mind here is:

(i) adults with qualifications in mathematics have access to a wider range of careers

(ii) mathematics is indeed 'a way of analysing and making sense of the world' as suggested by the non-statutory guidance. The best way I can explain this is by using an example of somebody feeling disempowered by mathematics.

I was listening to the news on the radio on the day when there was a protest at Westminster. A representative of a pensioner's group was being interviewed. The interviewer made a series of comments along the lines of "Well the government says that because inflation is only 2.3% and the VAT increase will be phased in over two years at lower percentage rates and the lump sum payment to your pension is equivalent to 8%, the increase in fuel will be naturally offset by these other factors". The pensioner replied somewhat crestfallen – "Well that's what the government always do – flummox you with percentages."

I have seen and heard many people disempowered by mathematics in this way. A teacher recently said to me that the most important thing about being a confident mathematician was that you didn't let people pull the wool over your eyes. A student summed this up once when he said,

"Mathematics is the only universal and non-racially motivated or discriminating facet of life that white society cannot manipulate for its own purposes."

I was somewhat taken aback by this statement as I had spent many years arguing that mathematics is not culture free and mathematics classrooms are certainly not free of the biases which exist in our broader society. Then I realised that this was the comment of a person empowered by their grasp of mathematics. Whatever anyone tried to suggest he could use his mathematics to analyse the situation and perhaps offer a different interpretation of it.

So that is why I teach – or that is why I think I teach at the moment. How about at the next department meeting you have in school starting off by talking about why you teach and why you think it is important to teach maths. It may not be to do with the nitty gritty of the national curriculum, but it is to do with the nitty gritty of education. Emma Brown wrote in MT147 that she felt empowered as a teacher and more in control of the National Curriculum once she decided how the document would be used in her classroom.

A primary school recently agreed that as a whole staff they would decide what they saw as the underpinning philosophy of teaching within their establishment. Below is the mission statement which they devised through discussion about what they saw as the purpose of education in general and the ethos within their school in particular. This mission statement is the first page in every curriculum document and is therefore used as a check for any piece of curriculum development. The question is often asked within the school, 'Does this idea fit our Mission Statement?', offering the school a way of 'delivering' the curriculum whilst remaining faithful to the whole school priorities for learning.

MISSION STATEMENT

1) We provide education in an academic school environment. We recognise:

i) The rich diversity of cultures within the school and community.

ii) Staff and children's respect and support for each other.

iii) The teaching staff use a variety of educational and assessment methods within, and extended from the National Curriculum as a way to assist all children to reach their full potential.

We value and celebrate the rich diversity within our community and ensure that equality of opportunity underpins our thinking, planning and practice.

2) We aim at a respectful and supportive partnership between parents and staff who are recognised for their high level of teaching and nurturing skills. Parents' concerns about the academic progress and social development of their children are recognised in terms of frequent and timely assessments.

3) We strive towards a strong community involvement and this enables us to offer a diversity of activities at all times. We celebrate all achievements together as a school and community and we work as a partnership each valuing the other, enabling us to offer a safe, well-resourced and welcoming environment.

If such mission statements are to be more than a paper exercise they must also provide a vision of what the school would look like in an ideal world. As an exercise I asked a group of students to analyse this statement and then describe what a school would be like if it was absolutely faithful to the mission statement. The students suggestions included

- Information board for parents in a clean, welcoming entrance hall including photographs of the staff.
- Feeling of team spirit and positive co-operation in the staff room which was tidy and had good displays of academic books and journals.
- Parents in evidence in the classrooms which are carpeted, contain interactive displays, and children engaged in purposeful activity.
- There is an effective behaviour policy based on positive reinforcement and respect between teachers and pupils.
- In lessons learners are making choices and initiating decisions, there is collaborative group work in evidence with an emphasis on co-operation rather than competition.
- The mathematics has clear links to learners' experiences and talk is expected. Learners are aware of and can articulate the purpose of the activity which they are engaged in.

The authors claimed that level 7 is that the problem is 'really(?) all about linear mappings'. 1974 was the heyday of the 'modern maths' movement! The article also explored some interesting geometrical slants.

Quilts (MT70)

Wendy Furey thought of this problem when she had to restitch the quilting on her sleeping bag. It was a 5 by 6 pattern and she wondered if all patterns were 'unicursal', or whether the manufacturers had chosen the 5 by 6 one because it was. Wendy explored the activity for herself and imposed the condition (a natural one if you are sewing a quilt) that having started in any direction you must keep going to the edge before changing it. She then tried it out with a small group of ten- and eleven-year-olds at an ATM London branch meeting. They quite quickly produced this table of results from looking at their drawings:

	1	2	3	4	5	6	7	8
1		1	1	1	1	1		
2		2	1	2	1	2		
3			3	1	1	3		
4				4	1	2		
5					5	1		
6						6		
7								
8								

and they were able to complete it without further drawing, with some help from Wendy. Wendy suggested some further questions in addition to the obvious one of generalising this table further. What is the length of the stitching? What is the area of the quilt and what area is contained by the stitching?

Pascal in colour (MT80)

The front cover of MT80 (see the front cover of MT150!) shows the patterns you get for modulo 4 and modulo 6. This activity, from the *Topics* feature, was suggested by David Rooke. He got his daughters, then aged nine and seven, to work on it on a rainy day. They gave their own account. 'The first thing we noticed was that the big yellow triangles stood out more than anything else. Also, that the whole triangle was made out of smaller triangles, and that the triangles were all different sizes. If you looked carefully some red squares in mod 6 were yellow in mod 3. If you changed some blue squares in mod 4 to yellow squares, you would get the same triangles as in mod 2.'

Squared paper turned through forty-five degrees works very well. At one ATM conference I saw people using canvas to embroider these patterns.

Motivation with a matrix (MT80)

This is another activity from the same *Topics* feature, contributed by G B Lawson from the University of Western Ontario. His eleven-year-old daughter had been given the problem and she had been surprised to discover that everyone in the class had obtained the same answer of 1976 (the year in which she was set the problem). Having discovered this pupils will want to know why it works, and G. B. Lawson explained this in his article. You might want to give your pupils the challenge of producing a table which always gives 1995 as the answer.

Five sticks (MT100)

This activity was mentioned in an article by Marion Walter, who was writing about a problem devised by David Fielker which first appeared in MT72. The questions posed are the first in Marion Walter's list of favourite questions about this problem. Others relating to the diagram given were suggested in the original article. As the fifth stick rotates, does the sum of the two short sides of the triangle change? How? Draw the fifth stick in many different positions superimposed. What shape is produced by the resulting set of lines? Mark a point on the fifth stick and trace the locus of the point. What shape is it? What shapes do you get by taking other points on the stick?
Are the endpoints of the rotating stick always moving the same distance as each other? When the triangle is isosceles what fraction of the square is it?

Some of the other questions about five sticks were the following. How many different pentagons can you make? How many different numbers of right-angles could you have? How many different numbers of crossings could you have?

Making a rectangle (MT120)

This is just one of the many problems posed by Marion Walter in her article *Generating problems from almost anything*, which was an edited version of the talk she had given at the Easter conference in 1987. She said that when she first saw the problem she wondered how you could find PD without knowing the lengths of the sides of the rectangle. She also wondered if there was some significance to the numbers 3, 4, 5. She asked if the fourth distance was determined by 3, 4, 5; and if the rectangle was determined.

Barbara Ball