HARD-TO-TEACH TOPICS: USING ICT PART 1

Ruth Tanner investigates teaching circle theorems.

How are teachers using ICT to support the teaching of topics considered 'hard to teach' in mathematics?

In November 2007 a joint ATM/MA team began working together to consider how ICT can be used to support the teaching and learning of topics that are considered to be 'hard to teach' in secondary mathematics, within a project that complements that of the Secondary National Strategy. In the best subject association spirit, we decided to advertise a call for 'successful' ICT-based teaching approaches to the teacher community via the ATM, MA and NCETM websites, targeted e-mails and advertisements in the ***TES***. The competition itself was won by Jay Timotheus of Blue Coat School, Walsall whose lesson described his use of handheld technology to provide a visual approach to the addition and subtraction of fractions and he won £200 worth of software for his school. All the teachers met at a one day conference to present their individual case study and participate in discussions to consider more deeply the pedagogic benefits of their ICT use in relation to the 'hard-to-teach' topics, and the best ways to disseminate this to other teachers. The resulting extended case studies will be published on the BECTA, and the subject association websites. Three of the studies have been filmed for a Teachers TV programme about the project '*Hard to teach: secondary maths using ICT*', and they can be viewed from the website.

One of the teachers whose lesson was filmed was myself and in this article I describe my lesson in more detail.

Background

I have noticed that students of all ages seem to find geometric reasoning difficult. They are taught a variety of angle facts, but seem to find it difficult to remember and apply these facts to solve problems. I decided to investigate whether it was possible for students to use dynamic geometry software to discover some of these facts for themselves. I hoped that they might then develop a deeper understanding that would enable them to transfer what they had learnt to the solving of angle problems.

For this project I worked with a top set Year 9 class in the summer term, about of third of whom achieved level 8 at KS3. I had been teaching these students since the start of Year 9, and we had already begun to consider the difference between *proof* and *example* in a variety of contexts. I decided to focus on some of the circle theorems included in the GCSE Higher Tier specification. I wanted the students to have a 'hands on' approach, but drawing and measuring lots of circle diagrams, even if given a sheet of pre-drawn circles, can be time consuming and tedious. I hoped that, with the use of dynamic geometry software, students would be able to generate vast numbers of examples quickly and easily, which would then help them to form conjectures, that some of them might be able to begin to justify and prove.

ICT was used in some form in most of the seven lessons; this varied from all students working in pairs at computers in a computer suite, to the use of a shared, projected, dynamic geometry image in an ordinary classroom. Obviously, an interactive whiteboard could have been used for the whole class work but the use of a relatively inexpensive graphics tablet[1] by the teacher, and the students, to manipulate the image was, I believe, almost as effective in promoting discussion and encouraging problem solving. Although we had access to a full class set of computers, it was a deliberate choice to get the students working in pairs so that they could support and help each other with some quite challenging tasks, and to enjoy the benefits of collaborative working which have been found to be so helpful in promoting deeper understanding and progress[2].

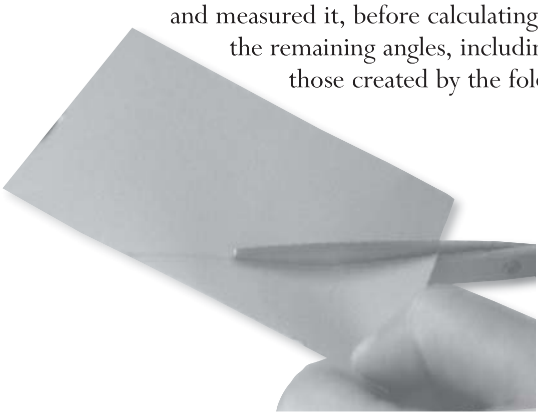
Preparation

Before the students started to tackle circle theorems, I wanted them to have some experience of the dynamic geometry software. So, working at computers in pairs, the students spent a lesson *playing* with the dynamic geometry software. They used a worksheet with detailed instructions for constructing a square, and then tried to construct other quadrilaterals for themselves. Hence the students began to get a feel for how the software worked, and what it was capable of, whilst also applying, and hopefully deepening, their knowledge of the properties of quadrilaterals. There was a lovely moment when, in response to a question about measuring lines, I stopped the class to demonstrate how to do this and another student contributed: "I've found another way…" and proceeded to show us all!

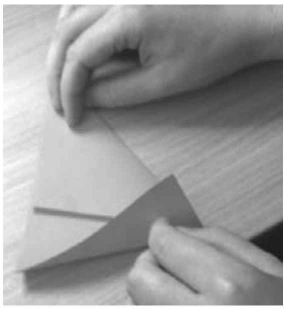
Shortly before I started planning this unit of work I attended an inspiring workshop, led by Pat Perks and Steph Prestage, entitled *The Ubiquitous Isosceles Triangle*. Pat and Steph argue that the isosceles triangle is at the heart of most of the geometry curriculum[3] and it reminded me that the properties of isosceles triangles are the key to proving many circle theorems. Consequently the next two lessons were spent getting to know isosceles triangles!

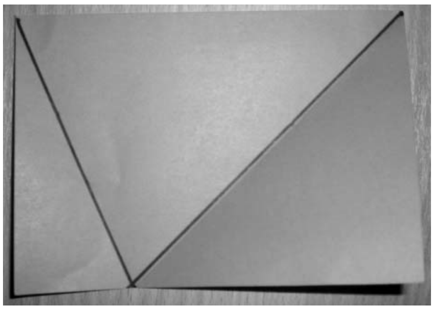
We began by folding a piece of paper in half and, with one cut, making an isosceles triangle (i.e. the fold line became the line of symmetry). Then, in response to: 'tell me about the shape you have made', we established the name of the triangle (isosceles) and its properties. Following Pat Perks and Steph Prestage's example[4] we agreed to call the non-equal angle the 'odd' angle and the non-equal side 'odd' side.

Through discussion, we established the nature of the symmetry, including the fact that the line of symmetry is the bisector of the odd angle, and the perpendicular bisector of the odd side. Finally the students chose one of the angles in their triangle and measured it, before calculating the remaining angles, including those created by the fold.



Next we all took an A6 piece of paper and folded an isosceles triangle (origami style).





The students then opened up their triangles and worked in pairs to *calculate* all the angles formed by the folds, giving reasons, before going on to *measure* the angles to check their answers. As an extension, some students did the same with an equilateral triangle.

For the next two lessons, the focus was on pencil and paper constructions using compasses and rulers. Again using some of Pat and Steph's ideas, the students were set small challenges including:

- construct all the possible isosceles triangles with 5cm and 7cm sides;
- construct isosceles triangles with 5cm for the equal sides. What happens to the *odd* angle as the *odd* side changes?
- After the students had explored this with paper and geometry equipment a shared dynamic geometry version of this was used to explore this further: what range of lengths for the odd side generate an acute odd angle? An obtuse odd angle? Is it possible to construct an isosceles triangle with equal sides of 5cm given any length for the odd side as a starting point? Why?

In this way students revised constructions of triangles and used the properties of isosceles triangles whilst also engaging in mathematical discussion and using their existing mathematical knowledge in a new context. The dynamic geometry software supported the discussion and questioning that the tasks provoked.

From here, we moved on to look at the way the isosceles triangle is at the heart of many of the standard constructions. For example, constructing an isosceles triangle above and below a line segment so that the line segment forms the odd side of both the isosceles triangles (not necessarily congruent ones!) and then drawing in the lines of symmetry gives the perpendicular bisector of the line segment.[5]

Finally we did a very quick revision of circle vocabulary that the students had already encountered.

Two lessons using computers

Now, with a basic knowledge of the dynamic geometry software and a heightened awareness of the properties of isosceles triangles, the students were ready to move on to investigate circle theorems. We had access to the computer suite for two lessons and for the first of these we were joined by Alison Clark-Wilson from the Chichester University and a film crew from Teachers' TV.

I considered a variety of approaches to using the software with the students. I ruled out giving the students files that already had the dynamic images constructed, or partly constructed, because I felt it was really important that the students started with a blank screen and constructed the situations for themselves, rather in the same way that they had cut and folded their own triangles in the earlier lessons.

Some time ago I produced a worksheet, in the form of an A4 booklet, which gave explicit instructions for constructing a series of dynamic images related to different circle theorems. For each image it asked the students to investigate what happened when, for example, they moved a point round the circle. I had used this with some success to introduce circle theorems, but not to move on to proving the theorems. I had noticed that some students raced through the activities, trying to get through them all as quickly as possible instead of spending time exploring each image fully and trying to make conjectures based on their observations.

With the key concepts and key processes of the new curriculum[6] in mind, I wondered whether the detailed instructions for constructing the images were actually necessary, or even a good thing! We all know that most students learn to use tools like dynamic geometry much faster than many of their teachers! Indeed, some of these students had already taught me new things about the software during their first lesson using it. However, I was also conscious that some students are not enthusiastic or confident users of ICT.

I decided to experiment with three different approaches:

- One group of students would be given a version of the detailed instructions for creating the dynamic images that I had used previously. However, in an attempt to try to stop them moving on too quickly to the next activity, I printed each activity on a separate A4 card, using different colours for each card. I hoped that this would make them appear to be separate activities and not one worksheet that *must* be completed!
- A second group of students were given the same activities. However, their instructions were about *what* to create, without any information about *how* to do this. For example the first card said:

> * Construct a circle.
>
> * Construct a triangle whose vertices all lie on the circumference.
>
> Make some conjectures about the angles you have created.

These activities were produced on small cards (six to an A4 sheet) and given out as a pack. Again I hoped this would reduce the tendency to race ahead to the next activity too quickly, but also be a more challenging, satisfying and creative approach for the more confident ICT users.

- The third group of students were also given a pack of small cards, but each of these cards had a theorem on it. For example:

> Show that:
>
> The angle subtended by an arc at the centre of a circle is twice the angle subtended by the same arc at the circumference.

These students were asked to use the software to construct an *example* to check their understanding of the property given and then to try to prove that the property is *always* true.

I selected the set of resources which I felt would be most appropriate for each pair of students and steered the higher achieving students to the cards which focused more on proof. However, the style of the resources was explained to them and the students were allowed to make the final decision for themselves. In the end, two pairs opted for the more detailed instructions, rather than the small cards that I had suggested for them.

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Editors' note:
This article continues in *MT214i*

1 www.tablet4u.co.uk/product.html?ItemID = 776

2 Standards Unit, *Improving Learning in Mathematics: a professional development guide, PD1-9*

3 Prestage, S. and Perks, P. (2006) The Ubiquitous Isosceles Triangle, *MIS 35/1*, January 2006, 2 also *MIS 35/2*, March 2006, 27 and *MIS 35/3*, May 2006, 9

4 Prestage, S. and Perks, P. (2006) The Ubiquitous Isosceles Triangle, *MIS 35/1*, January 2006, 2

5 Prestage, S. and Perks, P. (2006) The Ubiquitous Isosceles Triangle, *MIS 35/1*, January 2006, 2

6 QCA (2007) *Mathematics – The National Curriculum 2007*, http://curriculum.qca.org.uk/key-stages-3-and-4/subjects/mathematics/keystage4/index.aspx