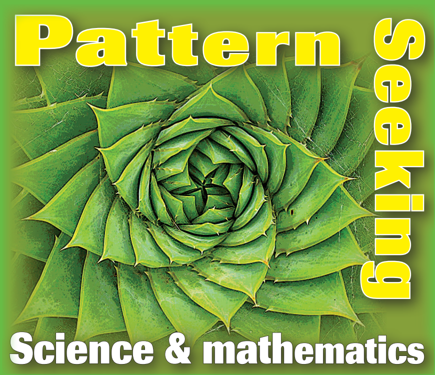

Figure 1 Have you ever looked closely at the centre of a daisy?

Marilyn Brodie and Nicky Fuller consider the maths of the natural world with activities based on Fibonacci numbers

FIBONACCI, FLOWERS AND THE GOLDEN NUMBER

Key words:
Creativity
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Observation

Have you ever looked closely at a daisy? Count the petals and then look at the yellow centre (Figure 1). You will see that the centre is not solid, nor even a random collection of tiny stalks, but is made up of spirals that go out from the centre. And it is not just daisies: look at the bottom of a pine cone and you will see the same spirals (Figure 2). If you count the spirals going clockwise and the ones going anticlockwise you will find that the numbers are different – wouldn't you expect them to be the same? To begin to understand this, the children need to learn a little about a mathematician from the 12th century called Fibonacci.

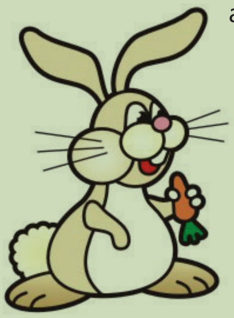
The Fibonacci principle

Leonardo Pisano (or Leonardo of Pisa, to give his proper name), the son of Guilielmo Bonacci, was born in Pisa, Italy, around 1175. He is better known as Fibonacci (Figure 3), a shortened version of *filius Bonacci* ('son of Bonacci'). His father was a customs officer (or the equivalent of this at this time!) in North Africa. In 1192, Guilielmo took his son to live and work with him in what is now Algeria and they travelled widely in this area. During these travels, Fibonacci learned about the enormous advantages of the mathematical systems used in the countries they visited. These systems, which were based on the 'Indians' nine symbols', had not yet been introduced in Europe, as many countries were using their own imperial systems, or Roman numerals; for example:
I = 1; V = 5; X = 10; L = 50; C = 100; D = 500 and M = 1000.

Figure 2 What do you notice about the spirals in the bottom of a pine cone?

Figure 3 Leonardo Fibonacci was a mathematician in the 12th century

Box 1 Fibonacci's rabbits



Fibonacci came up with his number sequence in the process of developing ways of using the 'new' numbers. He explained his sequence based on a hypothetical mathematical problem about rabbits:

- Suppose that when rabbits are 2 months old they are able to breed, and then every month after that they breed.
- Every time they breed one 'pair' of rabbits is born (1 male and 1 female).
- If each pair of rabbits breeds and none of the bunnies die, what would happen?
- At the beginning – nothing. So there is still only one pair of rabbits.
- At the beginning of the first month (January) there is still only ONE pair of rabbits (think PAIRS not rabbits).
- At the end of the second month (February) the female produces another pair so now there are TWO pairs.
- At the end of the third month (March), the original female produces a second pair, so now there are THREE pairs.
- By the fourth month (April), the original female has produced yet another pair, the female born 2 months ago produces her first pair, making FIVE pairs.
- And so on.

What was significant, which Fibonacci noticed immediately, was that there was no symbol for zero within the Hindu–Arabic system – only the digits 1 to 9.

In 1200 he returned to Pisa and used the knowledge he had gained on his travels to write a mathematics book called *Liber abaci* (*Book of Calculations*), in which he introduced the Latin-speaking world to the new numbering system, which he called *modus Indorum* (method of the Indians) and today we call Arabic symbols. The first chapter of Part 1 begins:

These are the nine figures of the Indians: 9 8 7 6 5 4 3 2 1. With these nine figures and with the sign 0 which in Arabic is called zephirum, any number can be written.

We take these numbers, and place value, for granted now and find it difficult to imagine what it must have been like to carry out even simple calculations without them.

Fibonacci had a section in his book devoted to weights and measures for merchants and businessmen and another for commercial bookkeepers, but he also had one introducing the Fibonacci number sequence – based on the calculation of the growth of the rabbit population! – a contribution to mathematics for which he will always be remembered (Box 1).

Using Fibonacci in the classroom

By spending time determining how the sequence has developed, children should begin to see an emerging sequence where the next number is the sum of the previous two numbers, and so can carry on for as long as they and their teacher wants. This is known as the Fibonacci sequence (Box 2) and the class can continue to produce a few more numbers in the sequence. The use of the Fibonacci sequence in school can be truly cross-curricular, with links to a number of different subject disciplines. However, the link with science and, in particular, nature is one that captures children's imaginations.

A Fibonacci hunt

For a long time mathematicians and scientists have noticed that the numbers in the Fibonacci sequence appear in many different patterns in nature. By examining flowers, seeds, fruits, and so on, and making their own 'flowers', children can learn a lot about the sequence while having fun.

Children can note the number of petals of a range of flowers and they will find that they fit with the sequence. For example, the peace lily has one petal (Figure 4) and a buttercup has five petals, both Fibonacci numbers. If it is not easy to access the real thing, a range of images of many more wild flowers can be examined using websites such as www.uksafari.com/wildflowers.htm. A word of caution when looking at cultivated flowers. The intensive breeding by gardeners of many flowers has meant that they may not have a Fibonacci number of petals, but this can be explored further. In fact, although the children may have made an eight-petalled rose, roses can have any number of petals; however, all originated from the five-petalled wild rose.

The seed heads of flowers exhibit the Fibonacci numbers if you count the number of spirals; sunflowers provide a good accessible example. Food items such as cauliflower and broccoli, can be examined for spirals, and Fibonacci numbers can also

Figure 4 A peace lily has one petal: you won't find many flowers with two petals!

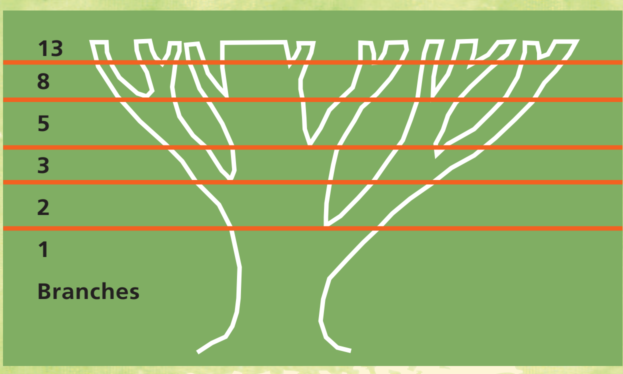
Box 2 The Fibonacci number sequence

0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233 …

Each number is the sum of the previous two and the sequence never ends.

Figure 5 Even simple foods such as apples and a lettuce illustrate Fibonacci numbers

Figure 6 If you draw a line at every new branching junction on a tree and count the branches, you also get the Fibonacci sequence



be seen, in apples and lettuce, both of which demonstrate the number 5 (Figure 5). It isn't only the flowers and seeds – a tree exhibits this principle as well, with the increasing number of branches as you move up the tree (Figure 6).

Making a Fibonacci flower

Making an eight-petalled rose from playdough is a popular activity linked to this topic. Other materials such as plasticine can be used, but playdough is softer and easier to handle. Each child follows instructions to make the rose. This can be done in the classroom on tables or in the hall on the floor, which the children love:

I liked making the flower and the maths. (Megan, aged 7)

My favourite part was making the flower. I want to make more at home. (Simon, aged 6)

Younger children will need quite close supervision, but generally the activity is straightforward. In making their roses the children learn about the Fibonacci sequence and other mathematics concepts, such as half – they have to break the original piece of playdough into two equal pieces and one of these pieces is then broken into eight equal parts (for the petals) so they can practise halves and quarters.

The final product is something they will be very proud of:

I really liked making the flower. I am giving it to my gran. (John, aged 6)

But of course the beauty of using a medium such as playdough is that if any child is not satisfied with their rose they can start again. The flowers can also be made from edible media such as marzipan or fondant icing (subject to a risk assessment taking into account nut allergies, etc.).

The golden number

Older children can explore the golden number, which involves a lot of measuring and calculation. The Fibonacci sequence of 0, 1, 1, 2, 3, 5, 8, 13, 21, etc. has another aspect. Once you get past the number 2, if you divide any number in the sequence by the number before it, the answer is always close to 1.618 – the golden number or golden ratio; for example, 21 divided by 13 is 1.61538. The Greeks knew about this, even if they did not call it the golden number. They discovered what they called the 'perfect rectangle'. It had proportions that, when its length is divided by its width, give the golden number. The children can spend some time measuring rectangles to determine their proportions. This work can then extend into art, architecture and so much more.

You may be wondering how the original question about daisies and pine cones relates to the Fibonacci number. Well, the spirals in many plants also relate to the golden number. If you count the seed cases on the base of a pine cone that spiral in a clockwise direction and then those spiralling in an anticlockwise direction you get two numbers, for example 13 and 8, which, when divided, give 1.6!

So, while ancient mathematics may not seem an 'exciting' topic at first glance, the cross-curricular nature of the work on Fibonacci can really stimulate in-depth discovery. So why not go out and find the golden numbers in and around your school?

Further information

There is a short Disney film on *YouTube* called *Donald in Mathmagic Land*, which is an excellent and entertaining source of learning about the golden number in nature, art and music. It lasts about 25 minutes but only the first 13 minutes relates to Fibonacci.

See: www.youtube.com/watch?v=YRD4gb0p5RM

Marilyn Brodie and **Nicky Fuller** work at the Centre for Science Education, Sheffield Hallam University and offer courses and sessions for teachers and pupils all about Fibonacci. These range from a single lesson to a whole day and are tailored to pupils from year 1 upwards. Email: **m.m.brodie@shu.ac.uk** or **n.a.fuller@shu.ac.uk**