THE MAGIC BOX – ENHANCING INTERACTIVITY

Dave Miller describes how to create and use a 'Magic Box' on an interactive whiteboard to enhance pupils' mathematical thinking.

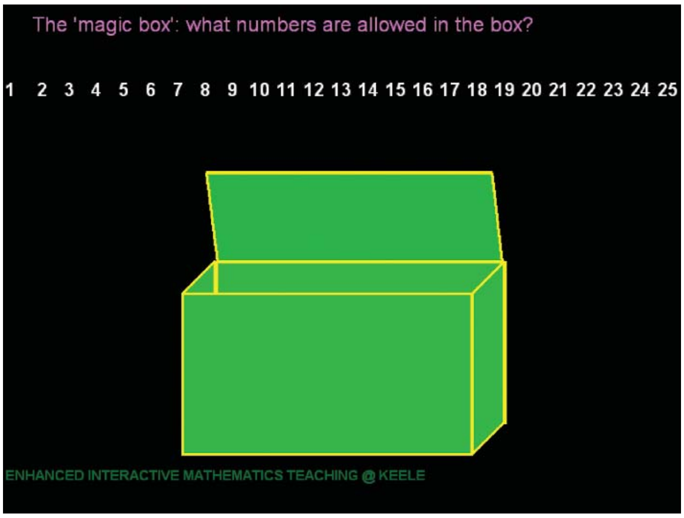

figure 1

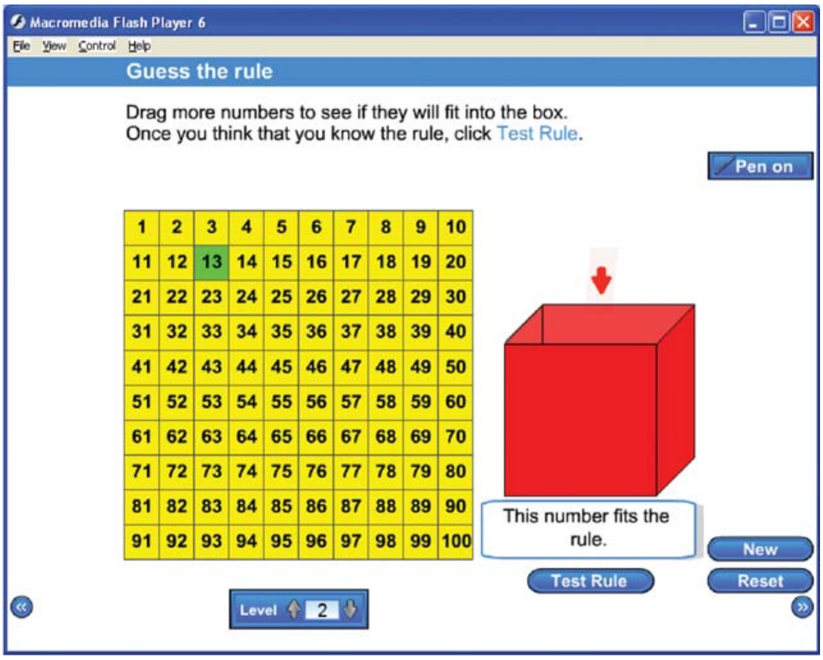

figure 2

The 'Magic Box' is an activity that we have developed from an idea originating, as far as we are aware, in a geography lesson. My colleague Doug Averis was first shown it by teachers following our Cognitive Acceleration in Mathematics Education (CAME) course. We have extended the idea from our original first thoughts to that which is explained here.

We consider it an interactive whiteboard (IWB) activity since the IWB 'manipulation', usually termed as 'drag and drop', is used to make an object 'disappear', or not, into a box. Although it might be argued that one can do the same thing using just a data projector, we consider it important that the teacher is actually at the IWB appearing to move the objects physically into (or not) the 'magic box'.

When you drag one of the numbers from 1 to 25 down towards the box it either appears to go into the box or it stays in front of the box (see *figure 1*, showing the starting position before any numbers have been moved). We present to pupils a question: "What is the rule, decided by the box (hence its name the 'magic box'), that allows numbers to go into the box or not?" We are going to describe some ways in which this simple idea can be used with pupils and at the end of the article we suggest how to create a magic box yourself.

Using the magic box

Suppose the teacher and class agree to try the number 13 first. It can be dragged down to see if it goes into the box. If it goes into the box, what can be said about the possible rule? This now opens up several ways of using such a program. One obvious way to use this is demonstrated in the *EXP Maths* Y9 program where the activity is a simple starter (*figure 2*, where the number 13 has been shown to go into the box) – pupils have to guess the rule after some numbers have been dropped. Numbers can be dragged to see if they drop through the box or are 'caught' by it. Once sufficient numbers have been 'caught' (shown in green) or have 'dropped through' (shown in orange), pupils can test for the rule of the box. The program randomly decides the rule – which has advantages and disadvantages. As an activity, it is challenging as a quick starter where pupils have to think about rules that a given set of numbers obey. Teachers have to use the program skilfully to ensure that guesses for the rule are not made too early (by limiting the class, for example, to one or two guesses).

However, although this starter has merit, more can be gained once pupils are used to using such a randomised program. The idea can be used as a main activity with software such as *ACTIVstudio*, *Smart Notebook* or *ActivePix* (though it can work, but not as effectively, in our view, using *Word*). In particular, it may help address the comments from the OfSTED report on mathematics (2005):

> *The capacity to reason, justify, explain and prove is central to being successful in mathematics. However, these qualities need to be explicitly developed and nurtured over time in just the same way as calculation skills or techniques for solving equations. Many teachers do not have a sufficiently secure understanding in the progression in these skills from one national curriculum level to the next. In many cases, pupils are not given the opportunity to develop these skills over time and, by key stage 4, they are only addressed in relation to GCSE coursework assessment rather than as an integral part of all mathematics learning.*

So what questions can be asked of pupils when the number 13 disappears into the box? What would you ask? Typically, from use of this with both experienced teachers and initial teacher trainees, many people assume that the answer is the prime numbers, or at the very least want to test another prime number. At this stage a good question is 'How many rules can you give that would allow 13 to be a number that obeys the rule?' So how many rules can you find that allow 13 to drop into the magic box?

Once a number of such rules have been established, written down and considered by the group, the next question to ask is 'What number should I test next and why?' Typically answers here will involve an odd number, an odd prime or 2 (because it is a prime), as people tend to look to confirm rather than look to eliminate possibilities. At this point it is possible to ask for lists of numbers that would obey any rule being tested.

Eventually, after discussion with reasons for choices, another number is tested (for example, 3) to see if it goes into the box. Imagine that it does – what more is learned and what rules are now possible? Again there should be time for discussion with a consideration of possibilities before another number is considered. This process can continue until people are confident that they have the correct rule. It is here that the skill of the teacher is paramount, drawing out possibilities with reasons, noting that it is easy to assume that given three numbers we might then be able to determine the rule. There are then different possibilities depending on the next number tested, though it is always necessary to state that we should never jump to conclusions too quickly based on testing a small set of numbers. One example of the danger of this is the well-known case of 1, 2, 4, 8, 16, ... leading to, amongst others,

- 32, 64, 128, etc (ie doubling);
- 31, 62, 124, 248 and 496 (the factors of the perfect number 496); and
- 31, 57, 99, 163, 256, etc (the quartic equation that gives the maximum number of regions produced when joining together points on the circumference of a circle).

The magic box activity can then naturally lead into a consideration of 'pictures' associated with different rules arising from the magic box. Examples of these where 13 obeys the rule are

- 1, 2, 3, 5, 8, 13, etc (Fibonacci numbers);
- 1, 3, 5, 7, 9, 11, 13, etc (odd numbers);
- 1, 4, 7, 10, 13, etc ($3n-2$);
- 1, 4, 9, 13, etc ($4n-3$);
- 2, 3, 5, 7, 11, 13, 17, 19, 23, etc (primes);
- 3, 8, 13, 18, 23, etc ($5n-2$);
- 5, 8, 13, 20, etc (n^2+4).

'Pictures' of the rule can include coordinate axes (*figure 3*) or shading the numbers on a hundred square (*figure 4*).

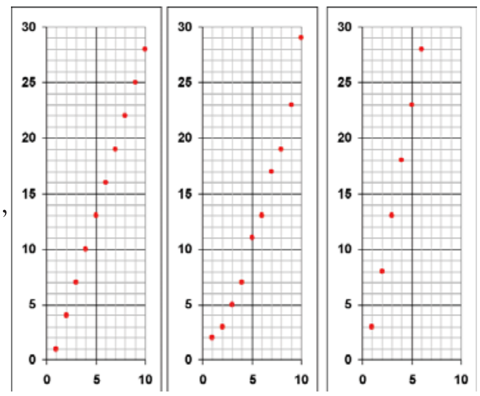

figure 3

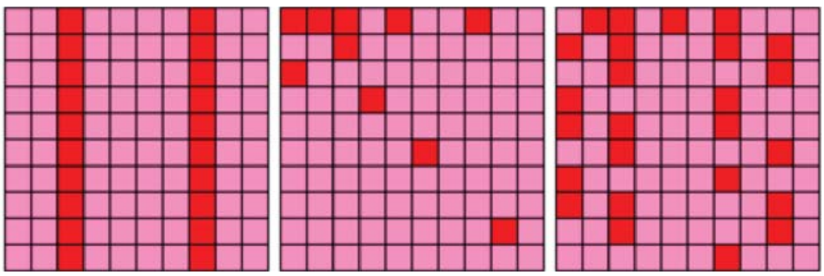

figure 4

There are many ways to follow through by asking questions like 'What is the same and what is different about any pair of these pictures?' and then looking, for example, at making other similar pictures to see what the magic box rules would look like (eg arrow diagrams). Clearly you might have other ways in which to develop the magic box and one of the key factors is how you use questioning to help pupils with their ideas and encourage them to reason. Note that adding more numbers (up to 100, for example) gives more scope for considering rules that can be tested.

Other magic boxes

It is also possible to extend the initial idea of the magic box into other areas of mathematics. Think about how you might do this before you continue.

Ideas that have been suggested before include

- cards showing equivalent expressions;
- polygons that have a particular property;
- equivalent fractions, decimals and percentages;
- expressions that are dimensionally correct;
- equations of graphs that have the same gradient.

Each of these ideas can be developed as a simple starter or extended into a task where the subject matter is considered in more depth.

Making the magic box

Whenever this idea is shown, people ask how to make the magic box. The *ACTIVstudio Professional 2*, *ActivePix* and *Smart Notebook* versions can be downloaded from www.iawmaths.co.uk, or you can make your own. In general terms you layer items onto the screen, and for all IWBs you can do this by arranging the order in which you copy and paste the objects. The quickest way to do this is given below, but it does assume some *Word* skills.

First make the back of the box (*figure 5*, which is a rectangle drawn, for example, in *Word*). Then use the 'camera' of your IWB software to add it to the relevant IWB screen. After this, make the numbers 1 to 25. To do this, create a text box in *Word* using the drawing toolbar, create the colouring to your taste and make sure the text is large enough (*figure 6*). Then use the 'camera' of your IWB software to add it to the same IWB screen. Now do the same for the rest of the numbers by changing the 1 to 2, then use the 'camera' in the same way until all the numbers are on the IWB. At this stage, leave them where they are until all are in place. Once all are in place, arrange them so that any one of them can be moved onto the back of the box without passing over (or under) one of the other 24 numbers.

You now need to make in *Word*, for example, the sides and front of the box (*figure 7*). The front of the box will be the same rectangle as the back of the box and you then need two identical sides. Create the left-hand side first, then the front and then the right-hand side and add them to the IWB screen in this order (using the 'camera' as before). Note that you will probably have to change the 'transparency' of the object if you are working in *ACTIVstudio Professional 2* or *Smart Notebook*. There may be problems of extra areas of white borders with other IWB software programs.

You now have all the parts you need and they are 'layered' so that the first item you copied to the IWB screen, the back of the box, is on the bottom, then come the numbers (with 1 lower than 2, which in turn is lower than 3, etc, with the final left-hand side, front and right-hand side of the box on top). This means that if you drag any of the numbers into the box they will all appear to go into it. You now have to change this, so separate the numbers into two groups (*figure 8*, where we have moved the smaller group, the Fibonacci numbers, down).[1] Then surround just the group that you do not want to go into the box, cut them out (using the 'cut' option on your IWB software) and then paste them back in (using the 'paste' option). This means that these will now not go into the box. Move them back into position.

Finally, to make different rules using the same

figure 5

figure 6

figure 7

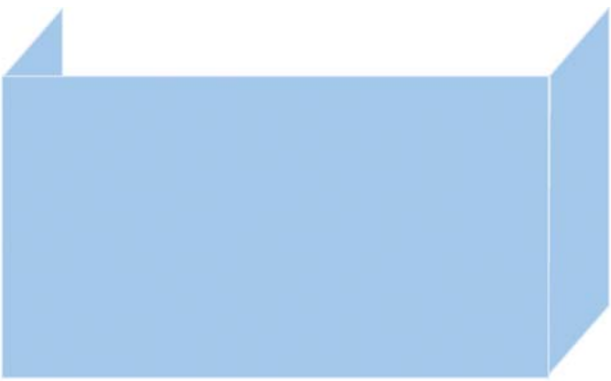

figure 8

numbers, remembering that you already have some that will go into the box, separate the numbers into two groups. First 'cut and paste' those that you want to go into the box, then 'cut and paste' the front of the box and then 'cut and paste' the numbers that will not go into the box.

You should now, in theory, be able to make magic boxes to use as widely as you like, remembering that the key to successful use is how you question your pupils and how they reason and explain.

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For more information about Keele University's research into the use of interactive whiteboards in mathematics lessons see www.keele.ac.uk/depts/ed/iaw/.

Note

1 For ***ACTIVstudio Professional 2*** users: For the back of the box, double-click it and change the 'appearance' so it is placed on the 'bottom' rather than the 'middle'. Then lock it in place using the right click menu. Then put the sides and front of the box in position and check that they are all on the 'middle' layer. Lock them in place. Separate the numbers into two groups – on our version you would move the smaller group, the Fibonacci numbers, down. Then surround just the group that you do want to go into the box and in one go change their layering to 'bottom'. Surround the other group and change their layering to 'top'. Move all that are necessary back into position. For new rules repeat these final two steps.

References

EXP Maths, Year 9, ISBN 0-7487-9041-1 www.nelsonthornes.com/secondary/maths/marketing/books_exp.htm

OFSTED (2005) *Ofsted subject reports 2003/04: Mathematics in secondary schools*, HMI 2326