Colour by numbers

- **Duration:** 45 minutes
- **Ages 5 to 7:** Lesson 1
- **Ages 8 to 10:** Lesson 1

Printables

Pixel Painter

Classroom resources

- Erasers
- Pencils

Learning outcomes

Students will be able to:

- Understand how images can be stored and represented using digits.
  Computational Thinking: Abstraction | Computer Science: Data Representation
- Understand that the images shown by computers are made up of pixels, each of which can display a different colour, based on digits.
  Computer Science: Data Representation

Key questions

- How do you think computers display images on a screen?
- How do computers store images if they store all information as digits?

Lesson starter

This lesson includes two activities: one that students complete individually and one group activity. In each activity you will need enough colouring pages for one per student. These each require different versions of the Pixel Painter worksheets. Use the **Black and White colouring type** (the first option on the list), and:

- For the first activity choose from the 1 page images (the star, teacup, or cat). You can use a combination of these images, students do not all need to complete the same one,
- For the second activity choose from the 6, 8, and 9 page images. Print enough for one set of image worksheets per group of students.

Notes on resources

- Print spare copies of each worksheet in case students make mistakes and need a new one.
- Use the **Black and White (2 possible binary values)** colouring option, **not** the option which says "in Run Length Encoding".
- Students can use a black colouring pencil, crayon, or felt tip pen, but easily erasable pencils work much better for the first time students do this activity.

Teacher to class: Computer screens are divided up into a grid of small squares, each of which can display a colour. We call these squares picture elements, or pixels.

Write the words "picture elements" on the board. To show how we get the word pixels, circle the "pi" of picture and the "el" of elements, and write "pixel" underneath.

Teacher to class: Each of these pixels can be a different colour, and when we have a lot of them on a screen they form an image. Has anyone heard of pixels before? What about megapixels?

Teaching observations

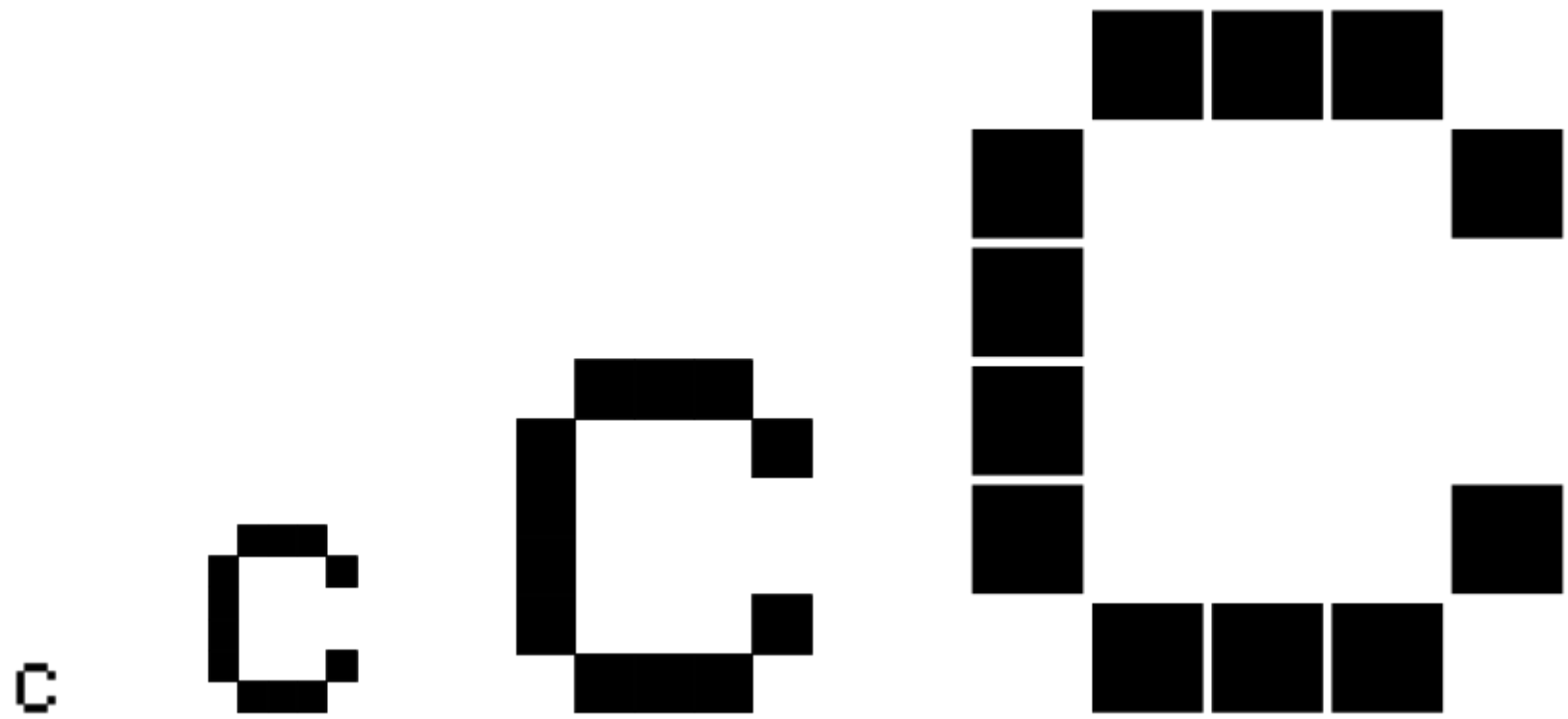
Megapixel means one million pixels. Students may have heard the term "megapixels" before because cameras are often described as being a certain number of megapixels, for example a phone might have a *12-megapixel* camera. This describes the resolution of the photos a camera can take. A 12-megapixel camera can produce an image with 12 million pixels in it.

Television screens and data projectors also display images using pixels.

Teacher to class: Every image we see on a screen, whether it is a picture, a video, or text, is shown using pixels, and all a computer needs to store is what colour each of the pixels on the screen should be.

Show the following images to students on a screen or on the board.

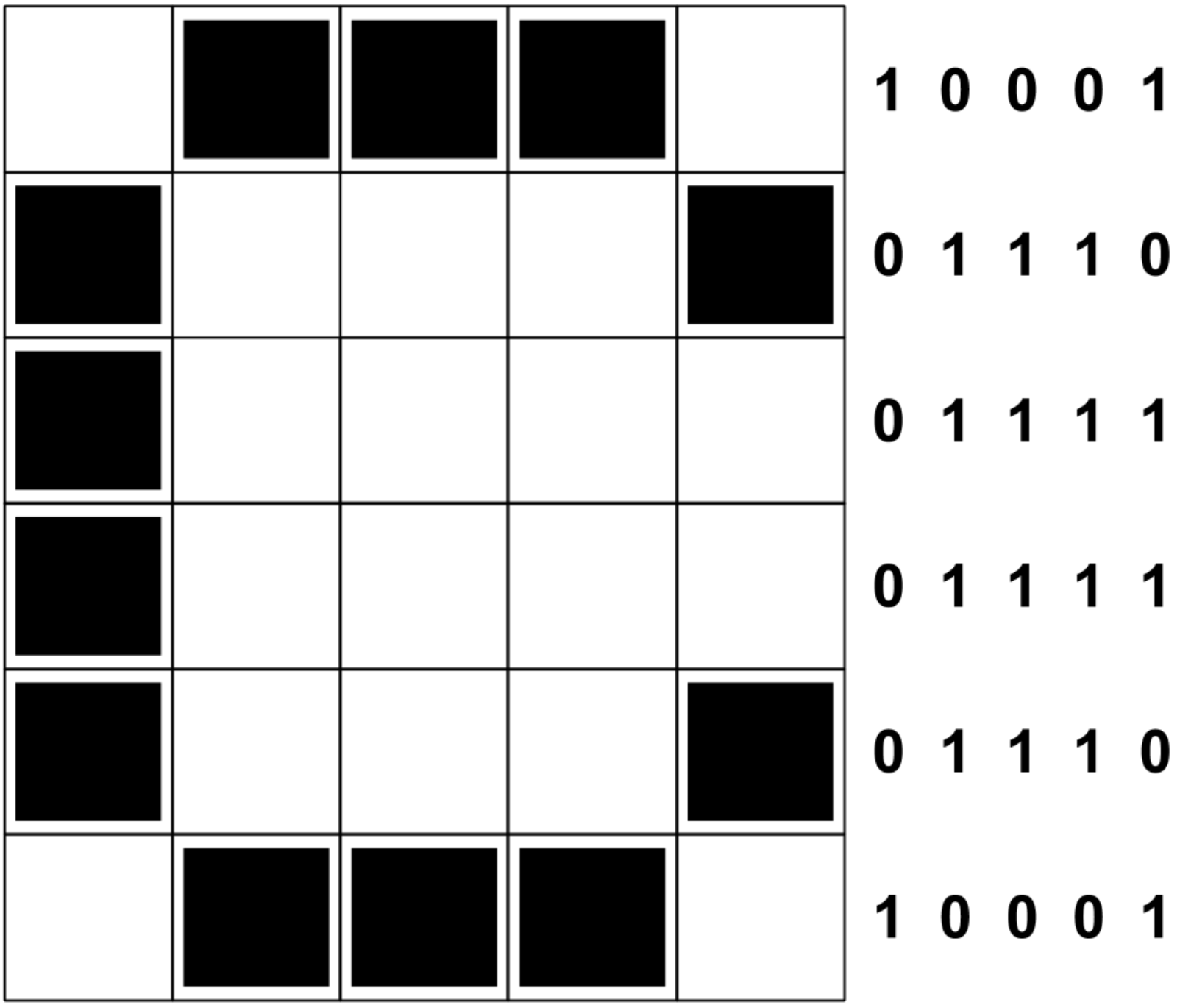
Teacher to class: In a black and white image, each pixel can be either black or white, so all the computer would need to store is which dots are black and which are white. For example, if we wanted to display the letter **C**, we first need to divide the letter into squares. If we zoom in further and further on the letter we can see a grid of pixels similar to these:



We can represent this image using binary digits (bits). If a 1 indicates a white square and a 0 indicates a black square then we can represent our letter **C**, on a 5x6 pixel grid, like this:

10001, 01110, 01111, 01111, 01110, 10001

If we take these numbers and draw the image they represent we get the letter **C**:



We are using 1 to represent white and 0 to represent black, in the same way we used white and black cards to represent 'on' and 'off' in the binary numbers unit.

Lesson activities

Hand out the 1 page image worksheets to students and ask them to look at the grid of squares. What do they notice about the numbers in the squares? They are all 1's or 0's.

Teacher to class: The grid on these sheets represents the pixels on a computer screen. Now you are going to be the computer and use the digits in the squares to make an image.

On the worksheets, have students colour in each square with a 0 in it black, and leave each square with a 1 blank so that it is white. We are using 1 to represent white and 0 to represent black, because 1 indicates that a pixel is 'on' (and therefore white) and a 0 indicates it is 'off' (and so it is black). By colouring the 0 squares in this activity, students are effectively 'turning off' those pixels. Advise them to colour them in lightly at first, and then when they are sure they have not made any mistakes they can colour them in fully. As they work through the worksheet they should see an image emerging.

Teacher to class: Now that we have made some simple images with our numbers and pixels, we can try making some more detailed and complicated ones. How do you think we could make more detailed images?

Teaching observations

Possible answers include adding more colours. This is a good answer and colours are part of more advanced lessons in this unit, but this lesson only focusses on black and white pixels, so bring students back to this and ask them how they can make a more detailed black and white image.

The may also suggest using smaller pixels for the same image they coloured in. This is a good answer and could be an idea for students to explore with in subsequent classes. For now we are looking at creating other more complicated and detailed images, rather than making the previous ones more detailed though.

The answer you are looking for is to use more pixels for the image, which is what students will do in this next activity.

Put students into groups and give each group a set of the multipage image worksheets, so that each student has a page to

work on. If this is not possible with the number of students you have just make sure groups are small enough for each students to have at least one page, or preferably for each student to have the same number of pages. For example, have groups of 3 work on a 6 page image, so each student has 2 pages to complete.

Teacher to class: These sets of grids can all be put together to create one larger image, which contains much more pixels than the previous ones. You are each going to colour in the pixels on your own sheet, in the same way as before, and then put the whole image together.

Once students have coloured in their sheets they can arrange them together to create the whole image. There are diagrams on the worksheet printables which teachers can use to help students put their images together if they get stuck.

Applying what we have just learnt

- Students could use a grid or graph paper to create their own images. Have students write out the binary digits that represent their image (in the same way as the 'C' in the lesson starter section, instead of writing the 1's and 0's into each of the boxes on the grid), give this to other students, and see if they can recreate the same picture.
- There are a number of websites avaliable that students can use to easily create pixel art. They can create their own pixel art, convert this into a grid of digits, and then have their friends try to recreate their image.
- Now that students have tried creating the larger images they could take it a step further and make an image as a whole class. The Pixel Painter Parrots option is made up of 32 pages, and is a great challenge for a class.

Notes on resources

There is an 8 by 8 grid in the printables section which can be used for drawing these images.

Lesson reflection

This lesson has just covered black and white images; why can't we do more than two colours with this activity?

- With one binary digit we can only represent two different values. This means if we use one digit to represent the colour of one pixel, then each pixel can only be one of two different colours.

What could we do to represent more colours?

- If we want each pixel to be able to show more colours other than black and white then we need to use more numbers (i.e. more binary digits) to represent the colour of each pixel. This will be explored in future lessons.