Key Stage 4 – Colour Coded

Notes for teachers

At a glance

A huge amount of data is transmitted and received using light down fibre optic cables. Currently that information is sent digitally using binary code (i.e the light can be 'on' or 'off' representing 1 or 0 respectively. Scientists from the QCUMbER project, led by the University of Oxford, are looking at clever ways to encode light with more 'colour' options than just on or off. Increasing the number of colour options, increases the amount of information each bit of light can convey.

Learning Outcomes

- Data is often converted into binary/digital code
- For light, binary means on or off
- If we could use 'colours' we could send more data with a single bit of light

Each student will need

- Student worksheets
- Coloured pens/pencils (optional, but better)

Possible Lesson Activities

1. Starter activity

- Ask pupils in pairs to discuss how Internet and TV signals get into your house. They may mention wires, aerials, satellite dishes, transmitters, receivers, etc.
- Explain that cable TV, internet and phone signals are often transmitted by sending pulses of light down fibre optic cables to your house.
- Give the students the student handout and ask them to read the first section.

2. Main activity: Binary Code

- Now ask the students to carry out the binary code task. They should be able to code all of the letters of the alphabet using 5 squares. It is usually easier if they approach the task systematically.
- (OPTIONAL) For more mathematically able students you could explain that the reason we know 5 squares should be enough is because we could, for instance, code all the letters as the numbers 1 to 26 in binary (base 2) which would be from 00001 to 11010. In fact, you could code up to 32 characters this way (from 00000 to 11111). If we had fewer squares, e.g., 4, we could only have 16 options from 0000 (zero) to 1111 (15 in binary).

3. Main activity: Beyond binary

- Show the 'What are quantum rainbows' animation (see weblinks).
- This shows, amongst other things, that scientists are trying to encode pulses of light (strictly speaking individual photons) with a range of quantum properties (which you can think of as colour).
- Give students the second handout and ask them to come up with a code using 8 colours rather than just black and white.
- (OPTIONAL) This is now effectively base 8 (as there are eight colour options). 26 in base 10 is 32 in base 8 (3x8+2) so two squares should be enough.

4. Plenary

- Ask students if they know any other codes that use flashing lights. They are likely to have heard of Morse code although they may need some prompting. Usually at least one class member will know the Morse code for SOS (dot dot dot; dash dash dash; dot dot dot).
- Point out that this is also a **binary** code. Unlike computers, humans aren't very good at judging how long a light is **off** for so it's hard to tell the difference between 10001 and 1001 for instance. It is easier, with some practice, to tell the difference between long and short flashes of light though.
- Ask students to research Morse code and send their initials (using light or tapped out on the table) to a partner to decode. [To make this a bit harder, they could send two random letters drawn from a bag, say].

Weblinks

- Oxford Sparks 'What are quantum raindbows?' animation: https://www.oxfordsparks.ox.ac.uk/content/what-are-quantum-rainbows
- Other resources on how we convert pictures (Picture This) and sound (Let's Get Digital) to numbers are available from Oxford Sparks: https://www.oxfordsparks.ox.ac.uk/content/teaching-resources
- Printable Morse code charts (4 to a page): http://www.apogeekits.com/PDF_Files/Morse_Code.pdf