LITTLE BIG FUTURES

Sensing fire with the Internet of Things (IoT)

INTRODUCTORY SCIENCE LESSON: TEACHER GUIDE

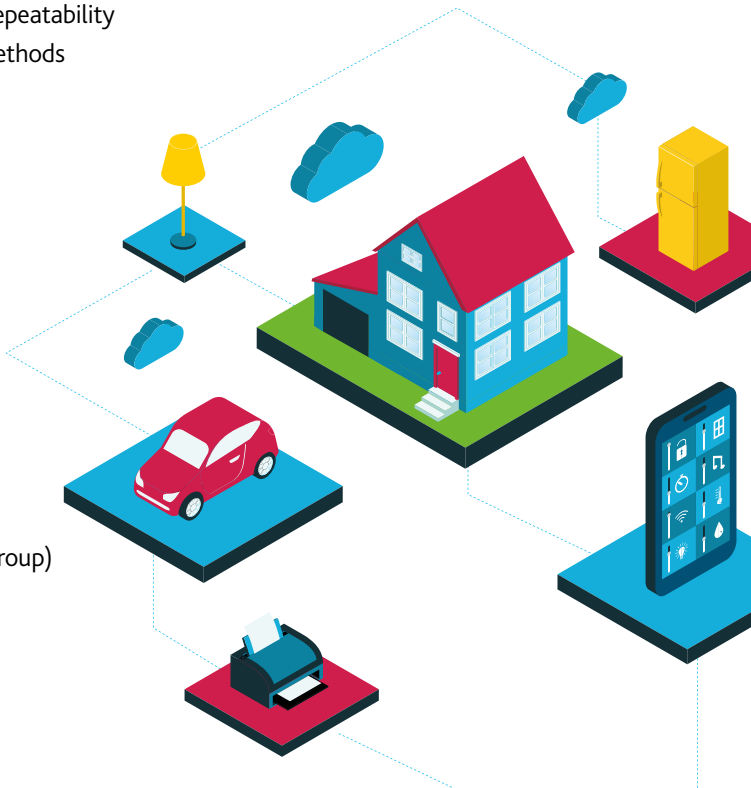
The IoT is already impacting on fire safety in areas such as fire prevention, detection and suppression, and firefighter safety. Connectivity of devices allows for integration into other smart systems, too, such as traffic control, mobile notifications, incident control and monitoring, utilities management such as water supplies… the potential for saving lives is huge.

This lesson examines the first part of the 'IoT chain' – sensors. Sensors detect and measure physical quantities and provide data, enabling decisions to be made by humans or computer algorithms. Fire detection can be achieved by sensing physical or chemical processes, or through human behaviour, and it is important that the right sensor is chosen.

No knowledge of programming, or prior knowledge of IoT or sensors is required for this activity.

Learning outcomes

- ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience
- pay attention to objectivity and concern for accuracy, precision and repeatability
- make and record observations and measurements using a range of methods for different investigations; and evaluate the reliability of methods and suggest possible improvements
- interpret observations and data, including identifying patterns and using observations, measurements and data to draw conclusions



Resources

- apparatus for class practical activity as listed on Student worksheet 2 (one set per student-group)
- student worksheet 1 (one per student-group)
- student worksheet 2 (one per student-group)
- teacher presentation (projector or other display needed)
- optional - access to the Internet for research work (one per student-group)

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Lesson activities

(1 hour duration; may be extended if appropriate)

	Activity	Resources
Activity 1 (5 mins)	**Introduction** Tell a brief story from the news about the devastation caused by a recent fire or an historical fire event. Explain the importance of early detection in order to limit the spread of a fire and protect lives (Teacher PowerPoint - slides 2 and 3). The aim of the following activities is to introduce your pupils to the concept of designing a device that can respond to a change in the physical world and produce an output that will affect an electrical circuit.	Streaming videos: General introduction to the 'Internet of Everything' Cycling accident Basketball Bananas Rock concert New year's eve power DIY store Cats and milk
Activity 2 (10 mins)	**Detecting a fire - a quick brainstorm to create a simple mind map** This can be done as a whole class discussion activity to create a class mind map or in small groups with the pupils creating group mind maps (Teacher ppt - slide 4). If Internet access is available the pupils could do some preparatory research. You may prefer to ask the pupils to read Student worksheet 1 as a starter activity to provide them with background information to create their mind maps. Alternatively, they could be given the worksheet as a pre-lesson, homework activity. Using ideas from the pupils, draw up a mind map on the board with Fire at the centre or show them the slide in the presentation (Teacher ppt - slide 5). Discuss which of the things that might be detected could be quantified to feed environmental data into the IoT (Teacher ppt - slide 5, highlighted in pink).	Optional - access to the Internet for research work (one per student-group) Student worksheet 1 Plain paper and pencils
Activity 3 (10 mins)	**Domestic smoke alarm demonstration** Show the pupils a typical domestic smoke alarm (ideally a photoelectric). Trigger the alarm (setting fire to a small piece of dry bread over a candle or Bunsen burner is an effective way to create enough smoke to trigger the alarm). Practice this before the lesson. Explain how the photoelectric smoke alarm works (Teacher ppt - slides 6 & 7). Explain to the pupils that there are a number of approaches to fire detection and that in this lesson they will focus on the increase in temperature rather than the smoke that is produced by a fire.	Domestic smoke alarm Heat proof mat Bunsen or candle Small piece of bread Tongs

Activity 4 **(10 mins)**	**Bimetal strip demonstration** At this point, if you have a large bimetal strip apparatus you could demonstrate this to the class, by heating it over a Bunsen burner. Alternatively, show them a short video of the demonstration (Teacher ppt - slide 9). To help the pupils to understand how one material expanding more than another can produce the movement observed, make models from two different coloured strips of cardboard about 15 cm x 2 cm (one to represent brass and the other steel). Staple the cards one on top of the other in the middle and at one end. Distribute these to the pupils, tell them to grip the unstapled end between thumb and index finger (Teacher ppt - slide 10). The top card represents brass. Now instruct them to push their thumb a millimetre or two towards the strip to indicate expansion of the 'brass'. The strip should bend down, with the 'steel' on the inside of the curve. Explain that the strip does not need to be made from two metals, just two materials whose lengths expand by different amounts (i.e. have different linear coefficients of expansion).	Bimetal strip demonstration Heat proof mat Bunsen
Activity 5 **(25 mins)**	**Making, testing and refining a heat sensor** Introduce the practical activity and explain the input, process, output structure typical of many IoT devices (Teacher ppt - slides 11 & 12). Explain that the pupils are going to design, make, test and refine a sensor to detect heat and produce an electrical output that could be used to switch on a fire alarm. Recap what the pupils already know about simple series circuits (Teacher ppt - slides 15 & 16). Explain the circuit to be used for the practical and recap the names and functions of the components and the fundamental principles of series circuits. Put the pupils into pairs or groups of three and distribute the apparatus (Teacher ppt - slide 16). Explain that the gap in the alarm circuit will be closed by a device responding to an increase in temperature (Teacher ppt - slides 17 to 19). After warning them about safe working practices ask the pupils to carry out the practical by following the instructions on Student worksheet 2. Using the answers to the questions (Teacher ppt - slide 20), discuss the pupils' findings from their experimentation. Ask how the sensor can be adjusted to change its sensitivity and how it might be incorporated into the IoT to improve fire safety.	**Apparatus per group** Two wooden blocks Buzzer Batteries Wires to connect up the circuit Aluminium foil to make four strips 8 cm by 1 cm Self-adhesive paper labels to make four strips 6 cm by 1 cm. Scissors Sticky tape Tealight candle Tongs Heatproof mat

Additional notes

Smoke alarms

The two most commonly recognized smoke detection technologies are ionization smoke detection and photoelectric smoke detection. The simplest of the two for the pupils to understand is the photoelectric. There is a diagram that explains how they work in the teacher presentation.

Circuit components

Standard circuit apparatus can be used. Buzzers are typically 6 volt so at least three, 1.5 volt cells in series will be required to make the buzzer sound. Experiment with strips of cooking foil and self adhesive labels to create bimaterial strips.

IPO control systems

There are three aspects to a fire alarm:

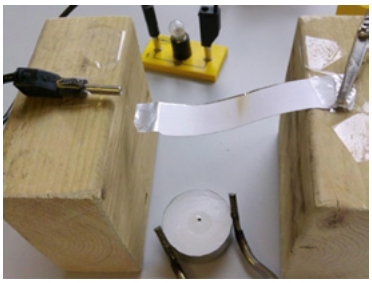
1. some form of input (produced by the fire) that can be detected by a sensor
2. a processor that 'decides' if the alarm needs to sound
3. some form of output that alerts the people in the house, usually a loud noise

This input-process-output (IPO) structure is common to a vast number of internet of things (IoT) devices and control systems. In the practical activity, the bimaterial strip provides an input, the electrical circuit, when switched on, triggers the output, an alarm (in this case the buzzer).

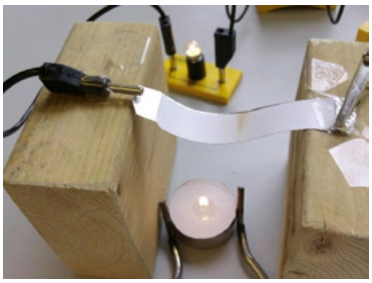
Thermal expansion

The coefficient of thermal expansion describes how the size of an object changes with a change in temperature. Specifically, it measures the fractional change in size per degree change in temperature at a constant pressure. Several types of coefficients have been developed: volumetric, area, and linear.

A bimaterial strip can be made by sticking a strip of self-adhesive label to a strip of aluminium cooking foil. Because the aluminium expands more than the paper the strip will curve towards the paper when hot.



Strip cold, contact open



Strip hot, contact closed

N.B. If the pupils leave the tea light under the strip for too long the paper will scorch and the strip will need to be replaced.