Circuit training

Some basic electronics can help you demonstrate anything from noise monitoring to machine guarding, says David Towlson, and it will liven up your training sessions

IN the hit US TV comedy series The Big Bang Theory, Sheldon Cooper — a genius theoretical physicist with autistic tendencies — delivers a dismal lecture that has his students tweeting "KMN" (kill me now). He is advised that taking acting lessons might help his teaching. He is intrigued by the idea and concludes: "It might help if I could act as though I cared about my students and whether or not they learn."

Most teachers do care, but sometimes unwittingly act as though they don't. Teaching health and safety can involve a degree of technical detail. While slides, pictures, models, props and videos can help bring topics to life, we can also aid understanding with demonstrations, practicals or simulations.

There's nothing quite like the real thing. Teachers might initially plan to use real equipment to liven up classroom tuition — for noise measurement, for instance — then reject it as impractical on cost grounds. But for general health and safety training, there are now many good flexible, multi-tasking alternatives which either substitute for or simulate these devices.

This article will look at a few items from the lower-end hobbyist side that I have found useful in teaching. Technology should not have pride of place or distract from the message, but it is a tool that can help make sessions more interesting and memorable.

Noise generator

A piezo transducer, with integrated driver electronics, will generate sound, usually at a given frequency and intensity, depending on the driver circuitry. This is a very cheap noise generator for the classroom.

All you need to do is to crimp or solder the transducer's leads to a battery connector and attach a 9V PP3 battery. Using an iPad/iPhone app to measure the sound level, students can then experiment with the effect of distance, enclosures (like cardboard boxes) and multiple sources — you can afford to buy several transducers, they are that cheap. If you want to step out and have a little more variety, try a bare transducer. It's a little slimmer and can be used to generate a whole range of frequencies when connected to a suitable power source and driver circuitry, like the Arduino board.

On board

The Arduino is a small, cheap circuit board — about the size of a pack of cigarettes — used widely by hobbyists and electronics prototypers. The basic circuit contains a programmable chip with addressable sockets divided into inputs and outputs.

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Simple programs use signals from the inputs to control outputs. This means you can attach all sorts of inputs, such as sensors for temperature, light, acceleration and keyboard input from a computer, and control outputs, including servos, motors, lights, diode lasers and information sent to a computer screen. These components are commonly available from electronics shops.

The Arduino board is programmed using a simplified, Java-like programming language; the Arduino is simply attached to a laptop via a USB cable and the program loaded directly in seconds. The programming environment is free, multi-platform (it works on Windows and GNU/Linux) and comes with numerous sample programs called sketches. Once loaded, the program runs continuously, checking inputs and controlling outputs thousands of times a second. It is not necessary to fully understand the programming language as it's easy to adapt and experiment with the sample programs.

There are many websites and books (such as 30 Arduino Projects for the Evil Genius and Beginning Arduino Programming series) which detail starter projects, including the circuit diagrams, components needed and sample programs. The board retains the last loaded program, which runs the instant it is powered up. Power can be supplied by USB lead or battery.

A popular application is autonomous robotics, as widely used in warehousing and vehicle production facilities. Building a simple photovore (light-chasing) robot will use inputs from photoresistors to cause a wheeled robot (driven by motors or modified servos) to move towards a light.

From a health and safety teaching perspective, this can be used to demonstrate how, if not taken into account in the program, a robot may well just carry on regardless if a human is in the way, or conversely, inclusion of additional sensors (such as infrared light curtains) can modify the behaviour. You can build robotic arms using multiple servos.

Other Arduino applications include exploring vibration by attaching a three-axis accelerometer for measuring orientation and acceleration, sending the output to a computer screen. You can make flammable gas and smoke sensors or measure air velocity using a thermal mass flow sensor, becoming a thermal anemometer.

Life of Pi

The Raspberry Pi is a similar size to the Arduino and costs just £24. However, whereas the Arduino is a relatively basic programmable circuit, the Raspberry Pi is a fully functional computer, with computing power similar to an old Pentium processor, but usually running some form of GNU/Linux operating system; Raspbian is the popular choice but there are many alternatives. The Pi was developed by a charitable foundation to promote the teaching of computer science in schools.

To function, the Pi usually needs to be plugged into a power supply, keyboard, mouse and screen, at least initially. You might well ask whether it isn't better to use an old PC. But the Pi is small, cheap — removing any fear of breakage while tinkering — and consumes very little power. And it scores high for geek credibility.

The Pi doesn't need all those peripherals when it's up and running, that's just so humans can interface with it. Indeed, there are several ways to dispense with the peripherals (except the power supply) if you have your laptop around. The first option is to connect to a wired or wireless network and then log-in remotely using your laptop.

Alternatively, you can connect the laptop directly to the Pi using a network cable and, with a little bit of setup, use the laptop's keyboard and mouse to control the Pi. A little like the Arduino, it has input/output capability (via a GPIO header socket). You can use the popular (among computer people, at least) Python programming language to do similar things to those I have described for the Arduino, and more besides, in the fields of automation, sensing and robotics.

One specific health application is the e-Health Sensor shield. This is an expansion circuit board that connects onto either the Arduino or Raspberry Pi. You can attach nine sensors to monitor body parameters such as sweating, breathing, heart rate and blood. It is not up to medical monitoring standards but it will do to explore the effects of stress.

At school, especially in science and engineering subjects, we were used to discovering and reinforcing understanding through judicious exposure to demonstrations and experimentation. Modern technology — and now older, but considerably cheaper, technology too) should make this more accessible. You no longer need specialist equipment, tools or deep, geeky knowledge of operating systems or programming languages. And if you are a geek, you no longer need to hide in a shed; you can do more. ■

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The Arduino board doesn't look much but could add interest to a session on stress or robotics