SSERC Bulletin

Ideas and inspiration supporting science and technology for all Local Authorities

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Counting cells using a haemocyto

Within the *Cells and Proteins* unit of Advanced Higher Biology [1], "Aseptic technique and cell culture" is a mandatory course key area. Learners are required to be able to use a haemocytometer to make an estimate of cell count in a microbial culture and to use staining methods to estimate viable cell counts.

Figure 1 *- A conventional glass haemocytometer.*

A haemocytometer is a specially designed microscope slide with a counting chamber of known depth which has a grid etched on to its lower surface. The grid enables direct counts of cells in a standard volume of culture to be carried out. There has for some time been a set of guidelines for the use of a conventional glass haemocytometer (Figure 1) on the SSERC website [2].

However, in recent workshops with teachers of biology we have been using disposable plastic *C-Chip*™ haemocytometers (Figures 2 and 3).

Figure 2

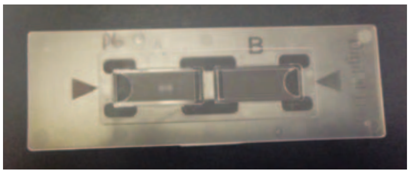


Figure 3

There are several advantages to using these haemocytometers in school:

- They are much cheaper than the conventional glass version: approximately £50 for a pack of 50, as opposed to £50 for 1 [3].
- They do not require coverslips
- They are virtually non-breakable

Here we wish to outline a suggested approach to using the *C-Chip*™ disposable haemocytometer in the classroom to make an estimate count of yeast cells in a liquid culture. Supporting resources are available from the SSERC website [4].

The challenges for students learning to use a haemocytometer successfully are often related to poor microscope skills. For those new to haemocytometers it is therefore important that they know their way around the microscope they are using and that they can use it appropriately to observe cell samples at various magnifications. We suggest that learners are supplied with a pre-prepared microscope slide and that they are given instruction and time to practise focusing, adjusting brightness, adjusting magnification and moving the slide around on the stage. Prior to introducing the haemocytometer, it might also be valuable for learners to examine a drop of yeast cell culture on an ordinary microscope slide so that they are familiar with the appearance of the cells at various magnifications before trying to count them. This will also provide further microscopy practice. Once learners are confident with the microscope, they can begin to become familiar with the haemocytometer. The *C-Chip*™ haemocytometer has two 'detection areas' (Figure 4) and therefore cells in two samples of culture can be counted.

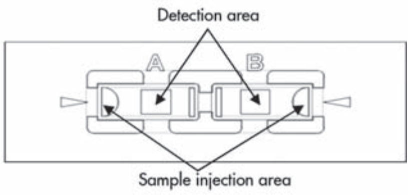


Figure 4 *- Image : https://www.labtech.com/disposable-haemocytometers.*

It is just possible to see the grids etched on the detection areas with the naked eye (Figure 5).

Once learners have seen the location of the grids they should be able to position the haemocytometer on the stage of the microscope so that light passes through one of the grids. It should now be possible to view the grid, initially using the x 4 objective lens (Figure 6).

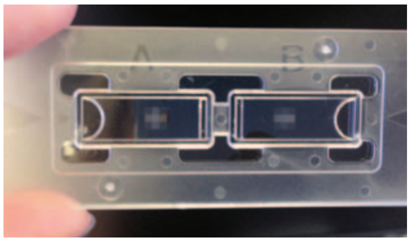


Figure 5 *- The grids.*

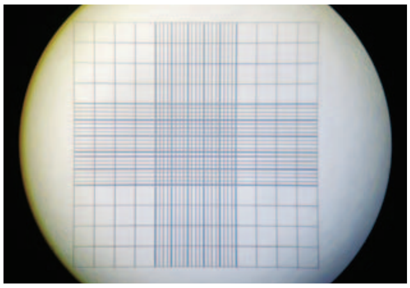


Figure 6 *- Grid viewed at x 40 (Magnification = x 4 objective lens multiplied by x 10 eyepiece lens).*

meter (it beats counting sheep!)

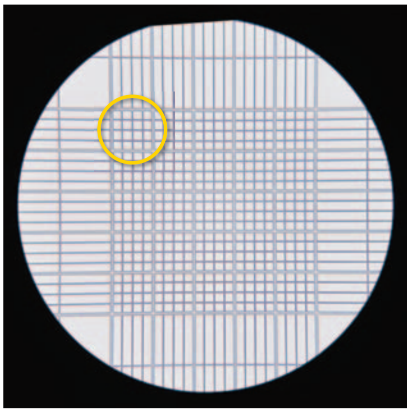


Figure 7 - Central area of grid at x 100 magnification.

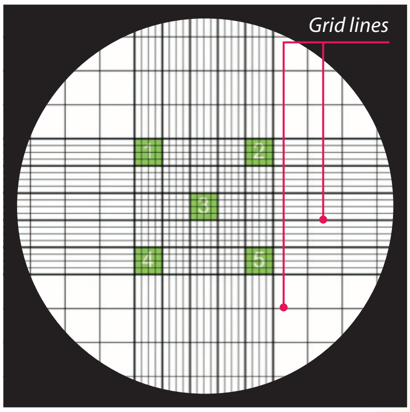


Figure 8 - Smaller sample squares.

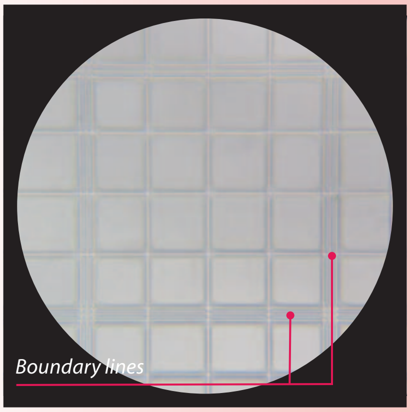


Figure 9 - One sample square; notice the 3 boundary lines around the edges.

Counting cells is done using the smaller squares which make up the central area. One of these is circled in Figure 7. At x 100 magnification learners should be able to see these 25 smaller squares and identify the 5 which will be used to sample the number of cells in the central area. A typical set of 5 sample squares is shown in Figure 8.

At x 400 magnification the sample squares (which themselves are comprised of 16 smaller squares) can be viewed individually - this is the magnification which will be used for counting cells (Figure 9).

Of course at this magnification the whole of the central area is not visible within the field of view and, therefore, it is tricky to find the sample squares without a bit of practice. The grid lines around the edges (Figure 8) help with negotiating the central area, but learners will need time to practise finding their way to each of the 5 sample squares.

As stated earlier, the *C-Chip*™ haemocytometer does not require a coverslip. Liquid samples are drawn into the detection area, from a micro-syringe, or capillary tube, by capillary action via the sample injection area (Figure 4). In our experience it is difficult to see colourless liquid samples being drawn in and the 'drawing in' happens quickly. We have therefore allowed learners to practise loading the haemocytometer using a coloured liquid before attempting to load a sample of yeast cell culture (Figure 10).

Once the yeast cell culture sample has been loaded, learners should be able to see cells at the different available magnifications, for example, x 40, x 100, x 400, and begin to think about counting cells at x 400 in the 5 sample squares (Figure 11).

The final instruction for learners relates to HOW to count the cells. Different laboratories will have different protocols for this, but the key point is to count systematically within the square (Figure 12) and to decide 'what's in and what's out'. ▶

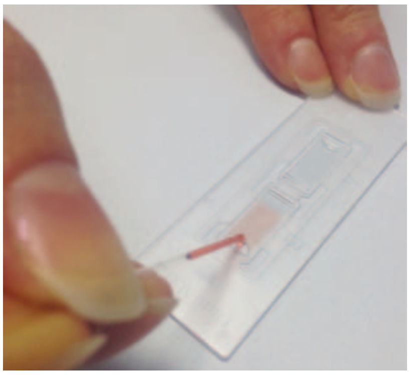


Figure 10 - Use a coloured liquid to practise loading the haemocytometer.

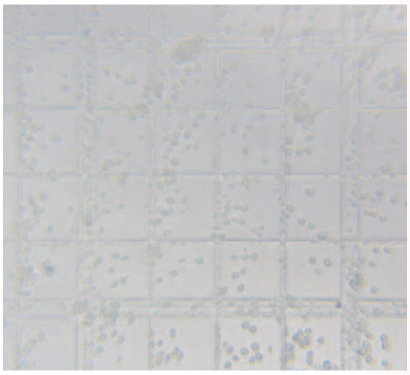


Figure 11 - Yeast cells in one sample square of the haemocytometer at x 400 magnification.

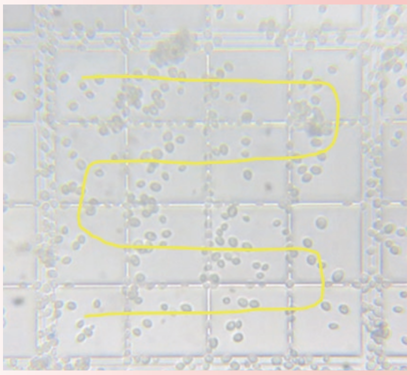


Figure 12 - Count systematically.

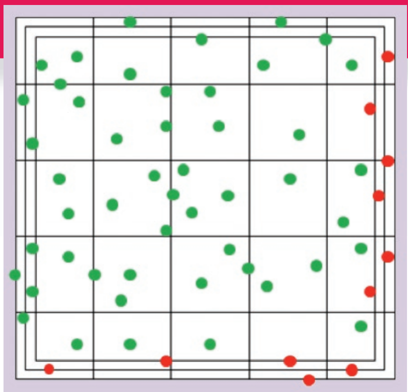


Figure 13 - Count all the cells within the sample square and those touching the top and left boundary lines (●). Don't count those touching the bottom and right boundary lines (●).

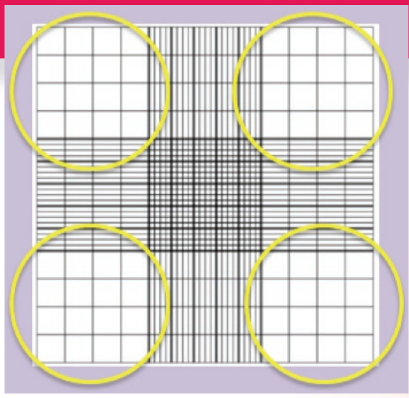


Figure 14 - The 'large' squares of the haemocytometer grid.

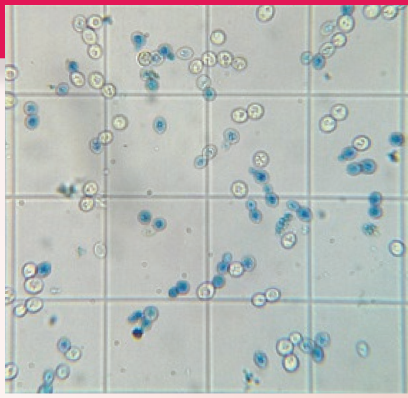


Figure 15 - Non-viable cells are blue (image: http://braukaiser.com/blog/).

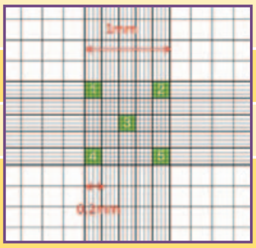
Figure 13 illustrates a system that might be used to ensure accuracy and consistency of cells counted.

Once the cells in the sample squares have been counted, an estimate of the total number of cells in the central grid of the haemocytometer can be made.

If the concentration of cells is very low, all the cells in the 25 square grid could be counted.

Volume in sample area (5 squares)

Length of side of central area	= 1 mm
Area of central area	= 1 mm^2
Depth under central area	= 0.1 mm
Volume under central area (25 squares)	= 1 mm^2 x 0.1 mm = 0.1 mm^3
Volume under 5 squares	= 0.1 / 5 mm^3 = 0.02 mm^3



For counting large cells, some protocols advocate using the 'large' squares of the haemocytometer grid (Figure 14).

If cell viability is to be taken into account, methylene blue can be added to the sample. Since live cells actively pump the dye out, viable cells are colourless and non-viable cells become blue (Figure 15).

For enthusiastic cell counters, or perhaps students carrying out an investigation involving enumerating cells over a period of time, useful 'apps' are available. We have used iPhone's 'HemocyTapp' (Figure 16). This will helpfully record counts of live and dead cells and will calculate cell densities and ratios in cultures. Data can be stored and e-mailed to the user.

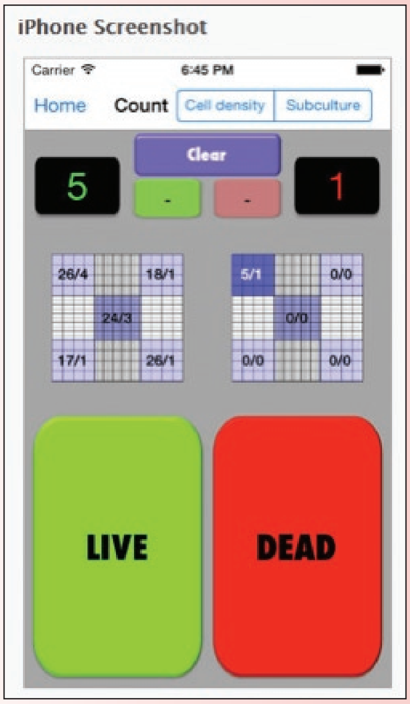


Figure 16 - 16 iPhone HemocyTapp (https://itunes.apple.com/us/app/hemocytap/id617767138?mt=8&ign-mpt=uo%3D4).

Estimating cell concentration

Number of cells in sample	= n
Number of cells in 1 mm^3	= n x 50 (because 0.02 mm^3 is 1/50 of 1 mm^3)
Number of cells in 1 cm^3	= (n x 50) x 1000

References

[1] Adv Higher Support notes: http://www.sqa.org.uk/files_ccc/AHCUSNBiology.pdf (accessed January, 2016).

[2] http://www.sserc.org.uk/index.php/biology-2/biology-resources/microbiological-techniques265/enumerating-micro-organisms141/982-counting-cells-using-a-haemocytometer.

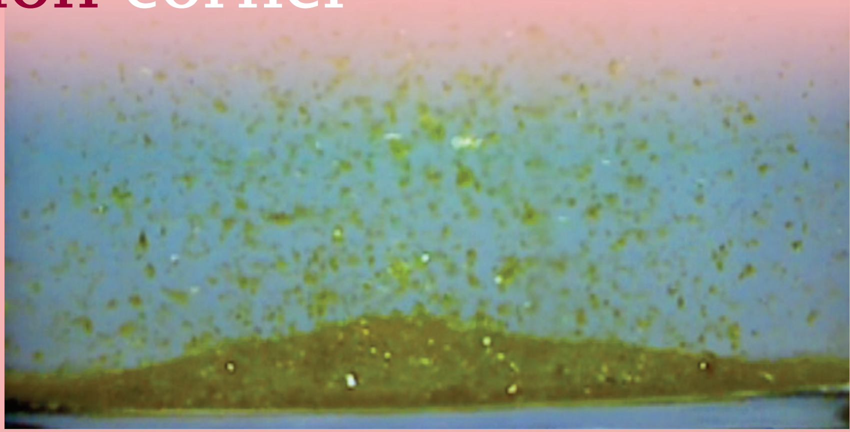
[3] Sourced from labtech.com: https://www.labtech.com/disposable-haemocytometers#slide-0-field_image-604.

[4] http://www.sserc.org.uk/index.php/biology-2/biology-resources/microbiological-techniques265/enumerating-micro-organisms141/3964-counting-cells-using-a-disposable-plastic-haemocytometer.

Demonstration corner

GOLDEN RAIN

This is a beautiful demonstration that is a lovely introduction to discussions about precipitation and solubility. If you want to do this on a larger, or smaller scale, just vary the quantities accordingly.



You will need

- 0.3% solution of lead nitrate (0.3 g in 100 cm^3 of water)
- 0.3% solution of potassium iodide (0.3 g in 100 cm^3 of water)
- A few drops of 1 M hydrochloric acid
- 250 cm^3 conical flask
- Dropping pipette
- Kettle and large beaker for a water bath or a hotplate.

Health & Safety

This is not a dangerous demonstration but it does involve the use of lead compounds, albeit at low concentrations: Wash hands thoroughly after the demonstration. Wipe up any spills and wipe over surfaces.

The demonstration

1) Prepare the solutions by dissolving the solids each in 100 cm^3 of distilled water.

   If you look at the stoichiometry, you will see that the potassium iodide is in excess: this is to maximise the chances of precipitating lead ions out of solution and reducing the possibility of washing away dissolved lead during disposal. When you have made the solutions, add a few drops of 1 M hydrochloric acid to each: this is to prevent the formation of lead carbonate which can be formed in impure water (including distilled water that has stood long enough for sufficient CO_2 to dissolve in it). Lead carbonate has a very low solubility and the haziness of its precipitate can ruin the effect.

2) Pour one of the solutions into the other. You will immediately get a brilliant yellow precipitate of lead iodide

   $$Pb(NO_3)_{2(aq)} + 2KI_{(aq)} \longrightarrow 2KNO_{3(aq)} + PbI_{2(s)}$$

   The tiny crystals of lead iodide that form swirl around in the flask and the concentration gradients as the liquids mix combine to generate a 'pearlescent' effect similar to that you might see in some shampoos or similar liquids.

3) Now heat the solution slowly, either in a water bath or on a hotplate.

   Whilst the lead iodide may be insoluble in water at room temperature, its solubility increases slightly with temperature. Put simply, when ionic compounds dissolve in water, they dissociate into their component ions. This dissociation can either give out energy (exothermic) or take in energy from the surroundings (endothermic), depending on the substance. In the case of lead iodide, it dissociates into Pb^{2+} and I^- ions. This is endothermic, and so increasing the temperature of the solution will promote the dissociation of lead(II) iodide. Consequently, the solubility of lead iodide rises from 0.0756 g per 100 cm^3 of water, to a still not very impressive 0.19 g per 100 cm^3 of water.

   The concentrations of the solutions are such that by the time the mixture reaches 60°C, all the lead iodide will have dissolved and the solution will be colourless again.

4) Leave the solution to cool, somewhere you, and your class can see it.

As the solution cools, the dropping temperature forces very pure crystals of lead iodide to precipitate back out of solution. These hexagonal crystals are larger than the very fine particles formed initially but they still take some time to meander gently to the bottom of the flask, giving the reaction mixture a shimmering, glittering effect commonly referred to as a 'golden rain'. The effect can last for up to an hour as the crystals fall out of the solution.

The effect is much better if you shine quite a bright light onto the flask. As the crystals tumble out of solution they reflect the light in tiny sparkles.

Disposal

Even though the iodide is in excess, there will still be some free lead ions in solution. Add a few cm^3 of 1 M sodium carbonate solution to precipitate out any remaining ions as lead carbonate (for this volume 2 cm^3 should be plenty). Filter the precipitates out and keep for disposal. The filtrate can be washed to waste with plenty of cold running water.

Let’s get ready

Coding can be an excellent context for collaborative learning experiences. In many schools coding is done on a PC and the outputs appear on the same screen that the code has been written on. There is a desire from many teachers that learners are able to ‘see’ a controller being driven by their code to produce an output on a device. Crumble controllers provide a low cost solution for schools to deliver a hands on experience of coding. Allowing learners to develop other skills associated with literacy, numeracy and construction.

The Crumble controller is cheap, easy-to-use and an ideal way to introduce electronic control and circuits to BGE classes. After starting out with a Crumble Controller, all you require is the addition of a battery power source, a micro USB cable from the PC, a number of croc leads and sparkle LEDs and you are ready to begin.

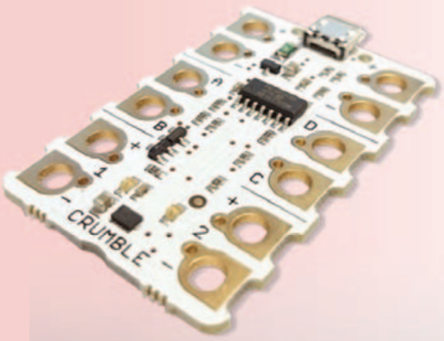


Figure 1 - Crumble Controller is well laid out and easy to use. Simply connect to the additional components and plug in the USB from your PC/laptop to begin. Costs around £10.

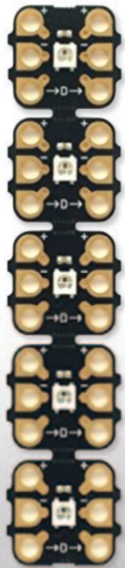


Figure 2 - Sparkles can be detached and used in any combination. The LEDs can display various colours and each sparkle requires its own programme sequence. Costs around £6 for 5.

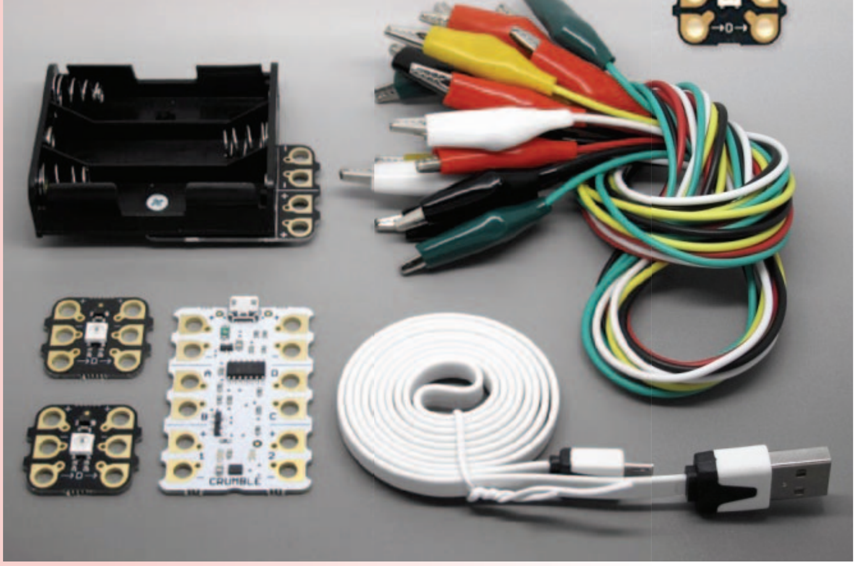
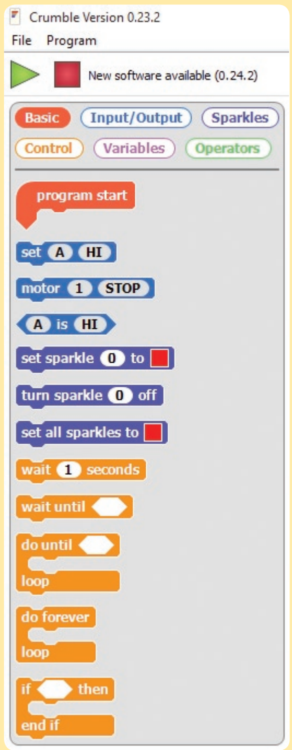


Figure 3 - Crumble starter kit (batteries/laptop not included). Costs around £17 per starter kit.

Crumble control software is free and available from the Redfern Electronics website [1]. The basic control options are shown below in Figure 4, and they allow a ‘drag and drop’ programme to be put together as a flow chart on your PC.

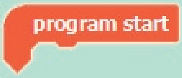


The free software is incredibly simple to use. With only a minimum of rules there are plenty of opportunities for pupils to collaborate and be creative.

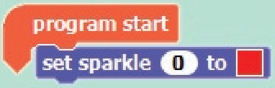
Figure 4 - Control options.

to Crumble

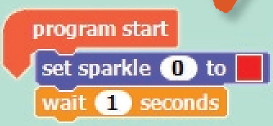
A simple click and drag system to be used when building a programme/sequence. Try this example:



Always begin with the PROGRAM START option.

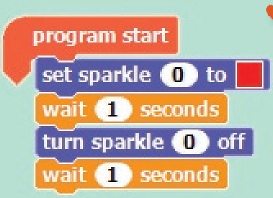


The first sparkle is always 0, then 1, then 2 etc. To select the colour click on the red box and choose from the wide selection.

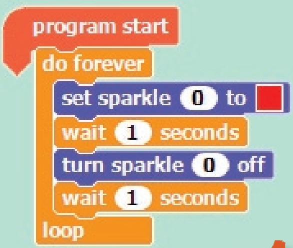


Tell Sparkle 0 to stay red for 1 second.

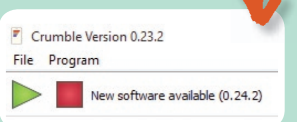
Turn Sparkle 0 off again and the red will disappear.



Keep the Sparkle 0 switched off for 1 second.



Finally select the DO FOREVER LOOP and the sequence will continue to flash red for 1 second then off for 1 second until told to do something different!



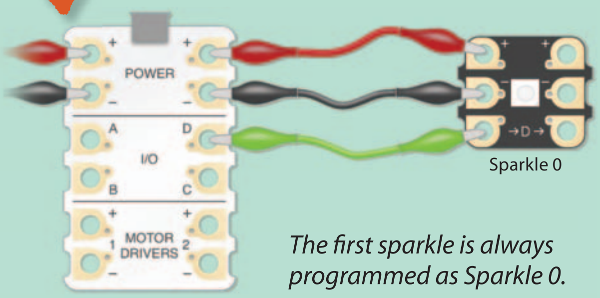
Select the green play button to begin (and then the red square button to stop).

Connecting the controller to the first sparkle

The code created on the PC is transferred to the controller through the micro USB cable

The micro USB is inserted from the PC into the controller dock here.

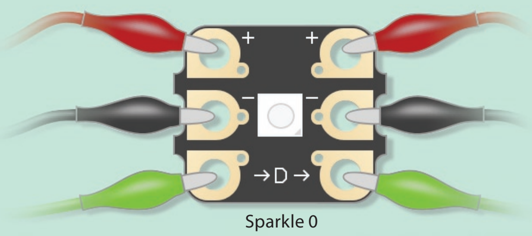
Red croc lead to battery +
Black croc lead to battery –



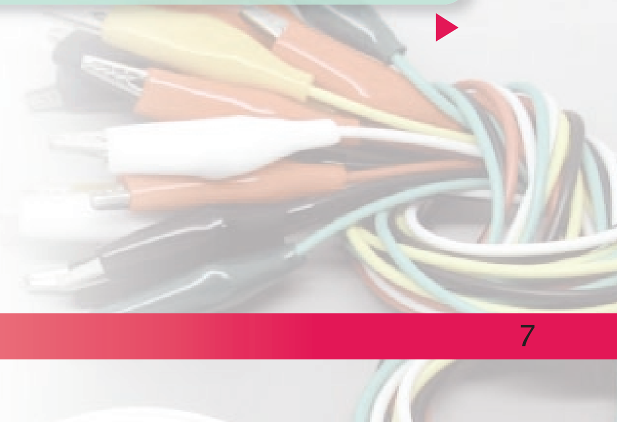
The first sparkle is always programmed as Sparkle 0.

Connecting multiple sparkles

Remember to keep the croc leads in sequence (+ connects to +, – connects to – etc.)



Up to 32 sparkles can be connected in sequence. Additional battery power may be required with high numbers of sparkles though.



Classroom challenges

After covering the basics of the Crumble format you can set a series of challenges to pupils who may work individually, in pairs or larger groups. These challenges encourage investigation, trial and error.

Task 1
Switch on one sparkle to the colour of your choice.

Task 2
Make one sparkle flash ON for 1 second then OFF for 1 second continuously.

Task 3
Make one sparkle flash RED for 1 second then BLUE for 1 second continuously like a police car.

Task 4
Use multiple sparkles and programme a sequence where only one is lit at any one time. Sparkle 0, then 1, then 2 etc. Set the timing to 0.5 seconds each and watch the lights 'chase' each other along the sequence.

Task 5
Information from the Northern Lighthouse Board website shows that the Ailsa Craig lighthouse flashes WHITE every 4 seconds. Create a sparkle to replicate this time setting.

Task 6
Use three sparkles to simulate a traffic light sequence!

Task 7
Create a sparkle sequence with as many lights as possible like a Christmas Tree (remember there's a control maximum of 32 though!).

Reference
[1] http://redfernelectronics.co.uk/crumble/.

Kath Crawford awarded an MBE

We are delighted to let you know that Kath was awarded an MBE for 'Services to Education' in the 2015 New year's Honours list.

Prior to joining SSERC in 1998 Kath held a variety of posts including time as a Research Associate at the universities of Cambridge and Kent, teaching biology at North Kelvinside and Queens Park secondary schools in Glasgow, and lecturing at both Stevenson and Telford Colleges in Edinburgh.

During her time with SSERC Kath has worked in a variety of capacities including several years when she spent about half of her time working as a Research and Development Teacher with the Science and Plants for Schools (SAPS) project. Kath has had a lead, and pivotal, role in the development and delivery of SSERC's CPD programmes culminating in her leadership of the on-going Primary Cluster Programme in Science and Technology.

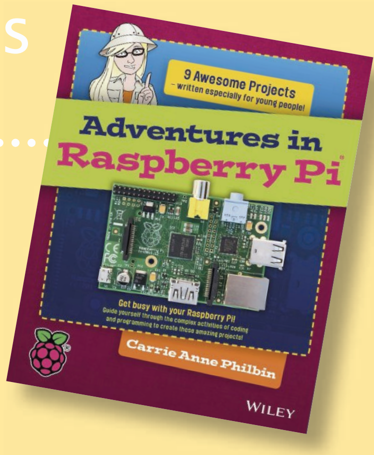
To Kath we offer our warmest congratulations!

REVIEWS

The introduction and uptake of Engineering Science in Scottish schools has sent Technical Education teachers scrambling back to their bookshelves for information and refreshers on electronics, processing and platforms.

With the reasonable prices of open source platform kits, more and more departments are better able to equip their classes with various components and connectors. What is perhaps missing is the teacher confidence in successfullyusing them. Here we consider two different popular titles that may help in your classroom.

Technology books



Adventures in Raspberry Pi, Carrie Anne Philbin

"This book will help you discover some of the amazing things you can do with your new Raspberry Pi, and introduce you to many of the developer tools and projects available to you." Quite a confident opening statement from the author and not too far off the mark either! There are loads of helpful explanation points that allow teachers who have little or no previous experience of using a Raspberry Pi to gain confidence in their use and understand some of the more quirky features that coding in a classroom can present. The glossary featured alone is excellent and can easily be adapted to a wall display to make the terms common language in your classroom. The '9 awesome projects' advertised will require some additional resources beyond the basic equipment, but with that comes the opportunity to merge different parts of the 9 projects to develop new and exciting ideas. This book is a fantastic opportunity to take your classes step-by-step through the guided lessons before allowing them free rein to take ownership of their learning and create independently.

Wiley 2015 - £14.99
(ISBN 978-1119046028)

Make: A Raspberry Pi-Controlled Robot (3rd Edition), Wolfram Donat

"In tackling just one project this book teaches you the basics of the Raspberry Pi, demystifies programming on Linux, outlines motor basics, and explains the different kinds of sensors needed to make a cool robot do cool things."

This title is a more advanced look at using the popular theme of robots to engage pupils with Raspberry Pi. Whilst it is quite a steep cover price for essentially one project, the author manages to justify it with the inclusion of GPS options, accelerometers and remote Wi-Fi connections, allowing the book to be relevant to more than one subject discipline within a secondary school. The additional equipment can be expensive to compile (especially if a full class set is required) but it is the attraction of cool robots that might just make the difference to pupils and conjure up enthusiasm.

MakerMedia Inc 2015 - £10.99
(ISBN 978-1457186035)

New STEM website

In December 2015, the National Science Learning Network and National STEM Centre teamed up and created a new website: www.stem.org.uk.

The new site sees all CPD activities, classroom resources, groups and blogs collected into one, easy-to-access place. You can search for resources and CPD activities filtered by Scottish levels.

The site can be customised around your needs and interests, bringing you the latest news and activities relevant to you. You can track CPD activities you have been on and manage upcoming bookings.

If you have an account on the National STEM Centre or have previously booked onto a CPD activity with the National Science Learning Network, you will automatically have an account on the new site, and will be able to access it with your current log in details.

Grant McAllister joins SSERC

Following a restructuring within SSERC Grant McAllister joined us at the end of October as Service Director. Grant will be well known to many as he joins us from Education Scotland where he was Development Officer for Secondary Science. Grant hopes his experience there will help partner agencies' work complement each other in supporting STEM teachers.

Grant started his teaching career at Kyle Academy in Ayr, before spending 10 years in a number of roles at The James Young High School in Livingston. Having completed an exchange year in Canada, Grant was appointed PT Physics at Bell Baxter High School in Cupar. He became Curriculum Leader at Bell Baxter in 2008. Grant has also been involved in developing materials for LTS, SQA and Scholar.

Grant lives in NE Fife with his wife, four children and their pet Labrador (Woody). Grant is delighted that in recent years he has given up golf to start playing rugby, which he also coaches.

From fireflies to poetry.....

One of the activities which SSERC offers to schools and colleges is a demonstration lecture entitled ‘From Sellotape® to Fireflies: things that glow in the dark!’. Suitable for all ages the lecture, as its title might suggest, covers a range of topics from across the sciences in which light is in some way involved in chemical, physical or biological effects.

National Poetry Day

The theme for the 2015 National Poetry Day on October 8th was ‘Light’ and so, at the invitation of Inverkeithing High School in Fife, the lecture was presented to S2 pupils as part of their build-up to the Day. After the lecture, pupils were encouraged to submit a poem based on their thoughts. One of the poems was written by Connall Wallace and we are delighted that he has allowed us to publish his contribution here.

The lecture is offered on a limited number of occasions each year and schools/colleges interested in booking the lecture should contact SSERC (sts@sserc.org.uk) in the first instance.

Light

Light surrounds us
every day.
Giving heat with its
photonic waves.

Light gives us
food to be eaten.
That burning ball of plasma
can’t be beaten.

Light allows for
us to exist.
Plants making oxygen,
using photosynthesis.

Light gives us
fireflies’ effulgence.
This reflects on their
bioluminescence.

Light gives us
fluorescent material,
Short to long wave lengths,
Just seems ethereal.

Light gives us
Vibrant rainbows.
White light being refracted,
What a show.

Light gives us
The universal speed limit.
Anything without mass or infinite energy,
Exceeds at it.

Light gives us
Fireworks using copper, sodium, lithium.
Brighten them up
with a splash of magnesium.

Black holes are
Lights only remiss.
Pulled back in with its
Gravitational supremisis.

Light is a
Beautiful thing.
So little covered
But so much to bring.

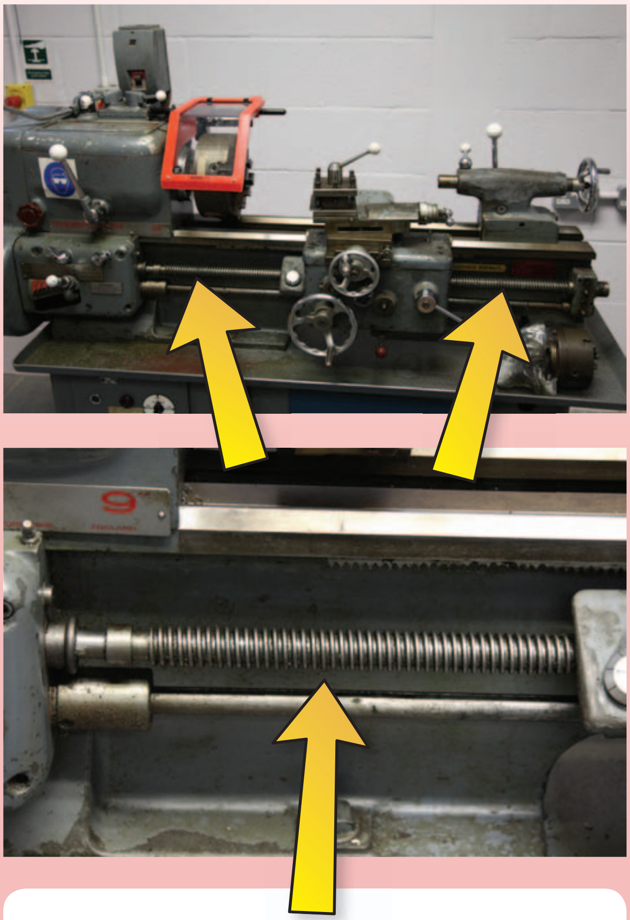
Conall Moyes Wallace (2015), S2, Inverkeithing High School

Make your lead screw safe

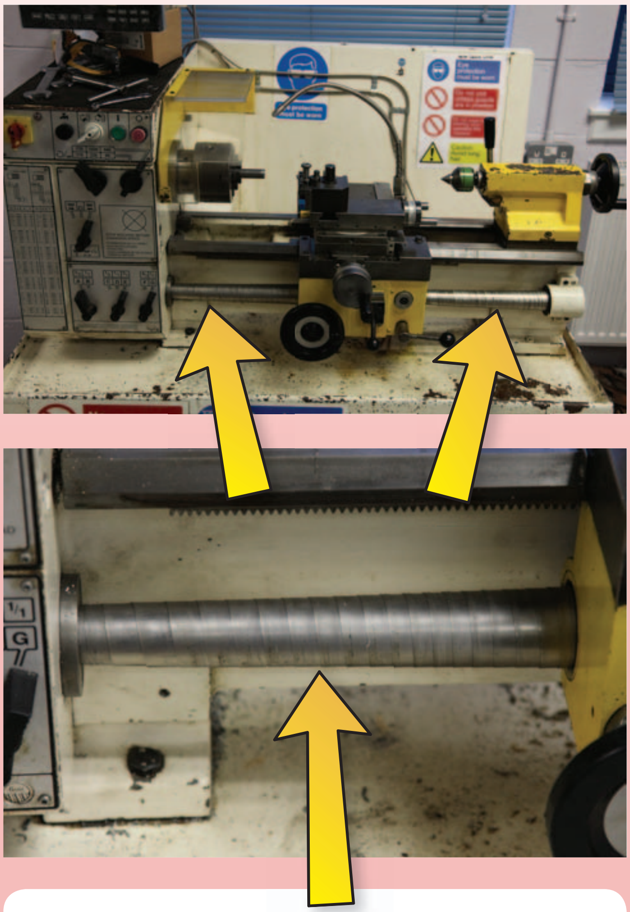
Sometimes, lead screws on school Centre Lathes may be covered by overhanging bedways. However, if the lead screw is exposed on your machine an appropriate guard should be provided according to the updated British Standard 4163:2014, Page 78. Rotating exposed lead screws provide a dangerous entanglement or trapping hazard to student aprons, long hair or loose jewellery.

However certain metalwork lathe designs are not suitable for guarding the lead screw, and in this case, as an alternative to guarding of the lead screw, the drive to the lead screw must be completely disconnected (by the removal of an internal gear from the lead screw drive mechanism). This action should only be completed by your authority's approved machine maintenance contractor.

If an exposed lead screw is required, a special risk assessment showing how the additional hazards presented by the unguarded shaft will be removed or reduced using appropriate control measures must be retained in your Technical Education Department's Health and Safety folder (paragraph 14.2.2 - BS 4163:2014).



This lead screw is exposed with no guard and presents an entanglement risk when rotating.



This lead screw has been properly guarded using a Spiroflex lead screw cover guard.

Electrical equipment - NSFW?

A lot of the equipment you buy for use in a school science lab will be mains powered. How do you know that it's suitable for work?

Recognised suppliers of science equipment

Anyone with desktop publishing or web design skills can give the impression of being a reputable vendor of science equipment. Most schools will have a number of teachers or technicians who have been around long enough to know who the big names are. That is not to say that a new company cannot be trusted to produce safe equipment. Nor can we assume that one of the established companies is beyond marketing or producing something that should not be used by children. Recent experience has shown that even some of the most respected names slip up. Fortunately, reputable suppliers have shown a great willingness to work with SSERC to put things right.

Supermarket specials

You could be forgiven for thinking that something put on sale to the general public would have to be extra safe. Unfortunately, it does not work that way. Take kitchen blenders. If you go into a professional kitchen, you may well see something that looks like your own blender but there will be a couple of important differences. The professionals' machine will have a recessed start button and a very prominent "mushroom" stop button. The reason is that this machine, compared to one at home, will get much more use in a high pressure (and if TV is to be believed, profanity-ridden) environment. Do not assume that something on sale to the general public is, therefore, suitable for the completely different circumstances found in a busy school science lab.

For these reasons, we have written this guide to give you some pointers concerning what to look for.

Plugs and leads

In an effort to save money, a number of manufacturers have been supplying equipment with plug top power supplies with interchangeable blades. The idea is that one power supply covers a variety of world markets and is adapted to do so via the provision of different plates with attached pins. Some of these designs are good - the locking mechanism is robust and any live contacts are covered until the plug top is snapped into place. Others, like the one in Figure 1, are poor.

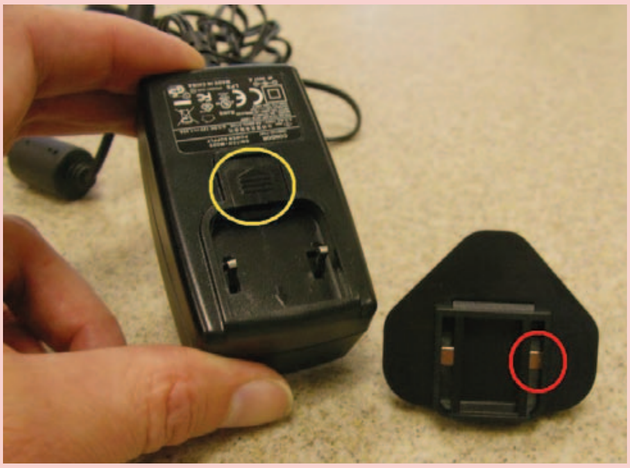


Figure 1 *- Plug top with detachable blade.*

The blade locking mechanism does not inspire confidence and, though slightly recessed, the live conductor could easily be touched with a coin, key or similar. If you come across something like this, make sure you risk assess it. Can you trust your pupils not to detach the blade or, if it becomes detached in normal use, not to touch the live part? If not, don't use it. In any event, please do let us know. Gratifyingly, all the suppliers who sent out kit like this have relented and begun supplying one piece plug top supplies. Watch out too for equipment with European-style plugs supplied with "shaver-style" UK adaptors.

Now have a look at Figure 2.

Figure 2 *- what's wrong with this plug?*

Figure 3 - Pupils might be tempted to stick things into vent holes.

Figure 4 - Well-designed mains fuse holder.

Compare this plug's width at the bottom with one bearing the British Standards Kitemark. It is much narrower, making it more likely that you will touch a pin when inserting or withdrawing it. The pins are half insulated, which is good in the case of live and neutral but bad in the case of earth. It could be possible to insert this into socket and for the earth pin not to make contact with a conductive part. What you probably noticed before anything else, though, is that there is no fuse. All of this is completely unacceptable. Again, we're pleased to say, the supplier agreed and replaced the lead.

Holes and vents

SSERC has worked with the British Standards Institution [1] to draw up guidelines for manufacturers of educational equipment. The hope is that this will be incorporated in BS EN 61010. At the moment, it is a standalone publication called TS 68250. As you would expect from a British Standards publication, test procedures are tightly defined. Regarding holes and vents in a piece of electrical equipment, as a rule of thumb, you should not be able to touch a part of the apparatus that would be hazardous live when in use with a probe made from an unfurled paper clip (Figure 3). As before, if you have equipment that does not meet this criteria, risk assess and decide whether you can trust pupils not to misuse it.

Fuses

In addition to a fuse in the plug, which is designed to protect the flex, a piece of apparatus may also have a built-in mains fuse. If this can be removed without the use of a tool, the equipment will fail its Portable Appliance Test (this is a criterion for mains equipment used in schools by pupils). Figure 4 below shows a well-designed fuse holder. The fuse cannot be removed by hand. Some sort of a tool, even an improvised one such as a coin, would be needed.

Dual voltage settings

Some "off the shelf" kit can be switched from 230 V to 110 V so that it can be used in America. Running an appliance at 110 V from a 230 V socket could cause dangerous overheating. If the equipment is for pupil use, check to see whether it can be switched from one voltage to another without the use of a tool. If so, do not let pupils use it. Taping over the voltage selector is not good enough - it is too easily circumvented. We know of some institutions that have used strong epoxy adhesives to fix voltage selectors to the desired setting. If you do this, you must be absolutely satisfied that pupils cannot unpick the glue and that it would not work loose with time. If a satisfactory fix can be made, its inspection should be part of the annual testing regime.

Cable security

Mains cables passing into the casings of appliances should be secured and should not abrade against the casing. The obsolete power supply in Figure 5 shows very bad practice. What is not evident from the picture is that there is a knot in the cable inside the casing to prevent it being pulled out. This is not good enough. There should be a proper cable grip - not merely a grommet - to hold it in place. An unsecured cable could break loose inside the equipment, causing parts to become live. A cable constantly rubbing against the edges of the entrance hole could wear, exposing a live conductor. We were taken aback recently to see an example of a cable passing unsecured into a casing on a piece of kit from a company generally highly regarded for the quality of their equipment. Note that we came across a case where a technical education department were getting students to design and make mains powered table lamps. Beautiful though many of the lamps were, we had to advise the school to discontinue the practice. Many of the lamps showed flaws related to cable security and, even for those which didn't, understandably nobody in the school felt competent to pronounce them as safe.

Rating plates

Somewhere on the body of a mains appliance you should expect to see rating information. If it is missing from a modern device, ask why. Figure 6 shows information on a metal-bodied power supply. Figure 7 shows the rating plate on a plastic-bodied plug top supply.

Note the "square within a square" symbol next to the CE mark. This shows that the appliance is "Class II". It does not need an earth wire because it either has two layers of insulation (double insulation) or reinforced insulation. Such insulation is designed to prevent any single fault causing an accessible part to be at a dangerous voltage. Most commonly, this symbol will appear on appliances that have non-metal casings. If you see this symbol on an appliance that has metal parts, be suspicious. They may be completely isolated from all hazardous live components or they may not. This does not apply to low voltage equipment run from a plug top power supply - it will be the supply that is double insulated. The low voltage kit does not need to be. Beware mismatches - for example, equipment with a two-core detachable cable but no Class II symbol.

CE Marks

The CE (Conformité Européenne) mark does not mean that a product has been independently tested and found to conform to the safety criteria outlined in a European directive. It is a self-certification scheme whereby a manufacturer asserts that their product does so. Some manufacturers employ independent assessors but others do not. Electrical equipment for use in schools must conform to the Low Voltage Directive. The bottom line with CE marks is that there should definitely be one, but its presence does not guarantee that the equipment is suitable for use in a science class.

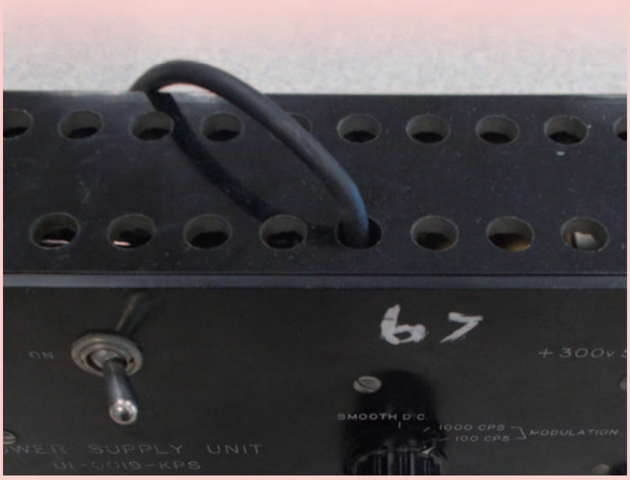


Figure 5 - No cable grip.

Thank you

All the issues raised in this article have been brought to our attention by conscientious teachers and technicians who have worried that something was not quite right about a piece of kit. Our sincere thanks for doing so. Keep up the good work!

Reference

[1] See SSERC Bulletin 241 "The Story of a Standard".

Figure 6 - Rating information on a metal-bodied PSU.

Figure 7 - Rating information on a plastic-bodied plug top PSU.

Radiation protection news

Disposal

In Bulletin 248 we reported on an anomaly in disposal regulations for radioactive sources. It was legal to put all currently recommended sources in the dustbin, apart from the protactinium generator and 370 kBq caesium sealed source and for them to be disposed of to landfill. Unfortunately, it was not legal for the bin lorry to transport the waste. This has now been rectified, although the restrictions on the protactinium generator and caesium source remain. Note that in the case of the caesium source, if schools keep it for a not-untypical 30 years, it will be able to be dustbin-disposed at that time if current legislation is not changed. Please contact SSERC if you want to dispose of a source.

Always ask SSERC...

- If you want to buy a new source;
- If you want to dispose of a source;
- If you want to transport a source.

You will not find guidance about disposal and transportation on our website (other than “contact SSERC”) because these are areas we always want to be involved in. With source purchase, you have no option - we must be involved.

Case study

An on-the-ball technician at one of our recent Radiation Protection courses realised that his school owned a source that should not have been bought. The school had not sought permission from the Scottish Government to buy the source, something done via SSERC, and the supplier failed to ask for a permission letter. The item in question was a 370 kBq caesium/barium eluting source. Unlike the 33 kBq model, this is not on the list of those recommended by SSERC and would have required an expensive permit to keep and use. At the time of writing, it looks as if the situation has been resolved with the help of SEPA. This could, however, have proved to be very costly for the school.

Explosions in school

It is reasonable to assume that if the words explosion and school appear in the same sentence, then something has probably gone badly wrong. Such events are thankfully rare but not unknown. The HSE has recently prosecuted a school in Bristol after a technician was badly injured in an explosion.

The technician who was injured was preparing Armstrong’s mixture, a highly sensitive explosive mixture of red phosphorus and potassium chlorate. Mixtures such as this can only legally be prepared by someone with an explosives license but even with one we would strongly recommend that this particular mixture (along with quite a few others) is simply not suitable for schools. The preparation of anything explosive in a school is an activity that should be approached with the greatest caution and only if there is a clear educational benefit that outweighs the risks. If you are in any doubt as to whether something is suitable to prepare or use in schools, contact SSERC.

Another cause of occasional fracturing of containers that can verge on explosions, though not so common these days, is organic waste bottles. If these get topped up piecemeal, there is always the possibility of something inappropriate being poured in which can lead to heating, vapourisation and subsequent shattering of the bottle.

We recommend that schools avoid having a standing organic waste bottle of this sort. The more things that are added to a mixture, the more chance there is of something unexpected happening.

If you have left over solvents, the best thing is to evaporate them in a (ducted) fume cupboard as soon as is convenient. If you do not have a ducted fume cupboard then they can be evaporated in a secure area outside in a shallow tray. If this is not possible then after each procedure, collect up the waste, put it in a bottle, labelled with the contents and the date, seal it and put it somewhere safe until the next chemical uplift. It is also sensible in this case to re-think the experiments that are carried out to see if there is a possibility of reducing the waste at source.

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