SSERC *Bulletin*

Ideas and inspiration supporting science and technology for all Local Authorities

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Effective Doppler experiments

In Bulletin 234, we published an article called *Higher Pitched* [1] about using the freeware sound handling package *Audacity* to demonstrate the Doppler Effect. It is a measure of the rapidity of change in the world of ICT that only two years later, we have a new method that is so much better it makes our previous efforts look almost embarrassing.

The latest method makes use of a piece of software called a frequency spectrum analyser. A screenshot from one is shown in Figure 1.

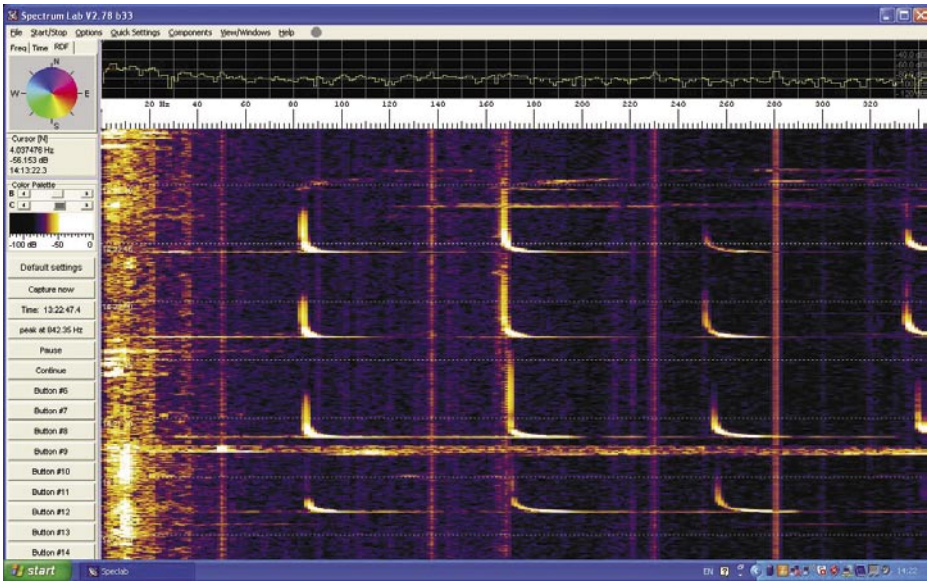


Figure 1 *- Frequency spectrum analyser.*

Referring to the main part of the screen, we see time on the vertical scale and frequency on the horizontal. The plot is of the sound from a sonometer wire that has been repeatedly plucked. We see a fundamental frequency of around 80 Hz and some harmonics at integer multiples of that value. The colour of the trace gives an indication of the amplitude of the sound though this can be determined more precisely by moving the cursor to the appropriate position.

Suitable free packages are Spectrumlab [2] for the PC and Baudline [3] for the Macintosh and Linux platforms. Apps are available for iOS and Android, but we found we had to pay a modest amount to get versions that allowed the user to zoom in on a narrow range of frequencies.

Figure 2 *- Smartphone signal generator app.*

We need a source of sound, preferably a reasonably pure tone. You could use a high frequency buzzer or Doppler Ball (see reference [1]) but we chose to install a free signal generator app on a smartphone. A number are available. We used one from Media Punk Studios (Figure 2).

This was our method:

- Set the spectrum analyser running, zoomed in to the frequency we had chosen to use.
- Move to a position some distance from the analyser.
- Switch on the signal generator. We chose a frequency of 5 kHz, because the larger the frequency, the greater the absolute frequency shift for a given speed.
- Check that the sound is being picked up by the analyser.
- Walk or run towards the analyser.

If we were doing this activity with a class, we would of course first demonstrate the frequency spectrum analyser, showing the effect on the display of varying the source frequency.

Figure 3 shows the results of one of our runs.

We see a steady vertical line towards the bottom of the picture. This represents the tone of 5 kHz being generated when stationary. As the person holding the signal generator walks briskly towards the analyser, the frequency is shifted upwards by around 30 Hz. Students can see this happening in real time. Should the sound source continue to move after reaching the analyser, the frequency will be shifted to a value lower than 5 kHz. Note that we do not yet know whether the ghostly purple lines to the right of the main trace are an artefact of the signal generator or analyser. However, we think that we do have a valid explanation for the faint apparent reflection of the main trace and we invite you to contact us with your own thoughts. You may also like to calculate the speed at which our tester walked through the SSERC lab.

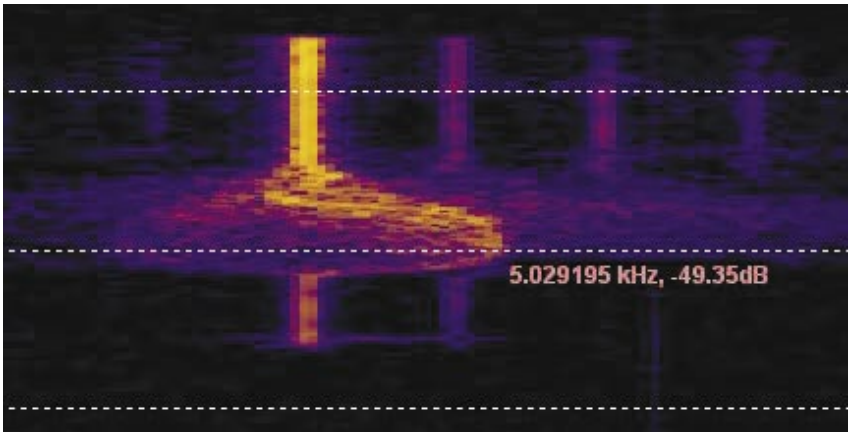


Figure 3 *- Doppler shift from moving signal generator.*

Figure 4 shows an alternative version of the experiment, where delegates at the 2013 IoP / SSERC Physics Teacher Summer School monitor the frequency from a signal generator carried by a cyclist, on their netbook computers. As there are analysers that run on small, portable devices, "moving observer" experiments are easy to do. We found that it was possible to see small Doppler shifts when the smartphone was gently wobbled in the hand, making it possible to model one method of exoplanet detection.

Can you trust an app?

According to developers, your smartphone can be a light meter, Geiger counter, signal generator, seismometer or frequency spectrum analyser. We have come across some applications that only "sort of" work. They do what light meters do, for example, but not very well. In the case of the signal generator app and PC freeware mentioned above, if all they did was to show qualitatively the Doppler Effect in action, that would be good enough. However, at SSERC we have calibrated test equipment and we are satisfied that the software we have used for this experiment is accurate enough for quantitative work in a Higher or Advanced Higher class.

Now imagine a galaxy of pupils all with smartphones generating a spectrum of different tones. Get them to recede from your analyser, and watch the red shift happen before your eyes.

Figure 4 *- SSERC person on a daft wee bike.*

References

[1] http://www.sserc.org.uk/images/Bulletins/234/Higher_Pitched-Doppler_Ball.pdf

[2] http://www.qsl.net/dl4yhf/spectra1.html (accessed June 2013). Note that we accidentally installed this on a memory card rather than the C: drive of our computer, and then accidentally discovered that it could run from the card on different machines without having to be installed specifically on them. Two helpful accidents.

[3] http://www.baudline.com/ (accessed June 2013). Not the slickest interface in the world, but it does the job. Just don't, under any circumstances, right-click.

Fertilisers and food security

'Food security is the provision of sufficient amounts of safe, affordable, nutritious food that we need to underpin the health and wellbeing of all the human population across the globe' [Prof. Julie Fitzpatrick (Scientific Director, Moredun Research Institute); 2012].

Figure 1 *- The Edinburgh skyline.*

The world is facing a potential crisis in terms of food security. The challenge is to produce and supply enough safe and nutritious food in a sustainable way for a growing global population, which is projected to reach 9 billion by 2050 [1].

How might one visualise such a large increase in population? Recent estimates [2] suggest that by 2030 we will need to create 1000 cities, each the size of Edinburgh, to accommodate the predicted rise in population in Africa alone.

As population growth continues there is an increasing demand for 'sustainable intensification' - the need for greater food production without increasing the land used for agriculture. Globally there is a need to consider how we might improve food transportation and issues dealing with food waste [3].

Food security is a broad theme which runs through the new science courses in Scotland and a range of learning and teaching strategies to support curriculum delivery are under development both within SSERC (many of these are available on our website [4]) and through external agencies (see, for example, [5] and [6]). The purpose of this article is to introduce some of the resources which we in SSERC are developing/adapting to support learning and teaching about fertiliser use.

Fertilisers are used to improve plant growth - they encourage faster growth of plants and are used to maximise crop yield. Fertilisers are also used where plants are showing signs of nutrient deficiency such as leaf yellowing but healthy soil structure and pH are just as important as fertiliser application in the prevention of plant nutrient deficiencies. Fertilisers contain concentrated sources of nutrients which plants need in relatively large amounts.

Most fertilisers are based on the three major plant nutrients:

- nitrogen (N) - for green leafy growth;
- phosphorus (P) - for healthy root and shoot growth;
- potassium (K) - for flowering, fruiting and general hardiness.

In the following pages we explore both a practical and discussion activity to support learning and teaching about fertilisers.

Figure 2 *- Germinating mung beans (image taken from http://cf.ltkcdn.net/vegetarian/images/std/121613-425x282-Mungbeans.jpg).*

PRACTICAL ACTIVITY
Investigating Nutrient Deficiency in Mung Beans

(This protocol was adapted from one kindly provided by Roger Delpech of The Haberdashers' Aske's Boys' Schools, Elstree).

The aims of the activities involved in this practical are:

- to investigate how lack of chemical nutrients (nitrogen, phosphorous and potassium) affects the growth and development of mung bean plants;
- to identify mineral deficiency symptoms associated with lack of particular nutrients.

Background

Mung beans are native to India and grown extensively throughout the tropics as a food source. They are legumes and provide an excellent source of protein and potassium in the diet. They are also eaten as bean sprouts. In some countries mung bean plants are grown alongside rice in paddy fields as they have extensive roots which help retain soil and, being leguminous, they add nitrogen to soil.

Mung beans are cheap, reliable and easy to germinate (Figure 2). Germinated mung beans can be grown quickly in a range of water culture solutions - standard Sach's solutions can be used for this. Growth in distilled water makes a good comparison.

Within a few days learners will see differences in the growth and development of seedlings and can make comparisons and draw conclusions relating to mineral deficiency symptoms and requirements for healthy growth. The seedlings will grow for 10-14 days (Figure 3).

Time lapse photography can be used to capture images of seedling growth - an example of this is available on the SSERC website [4].

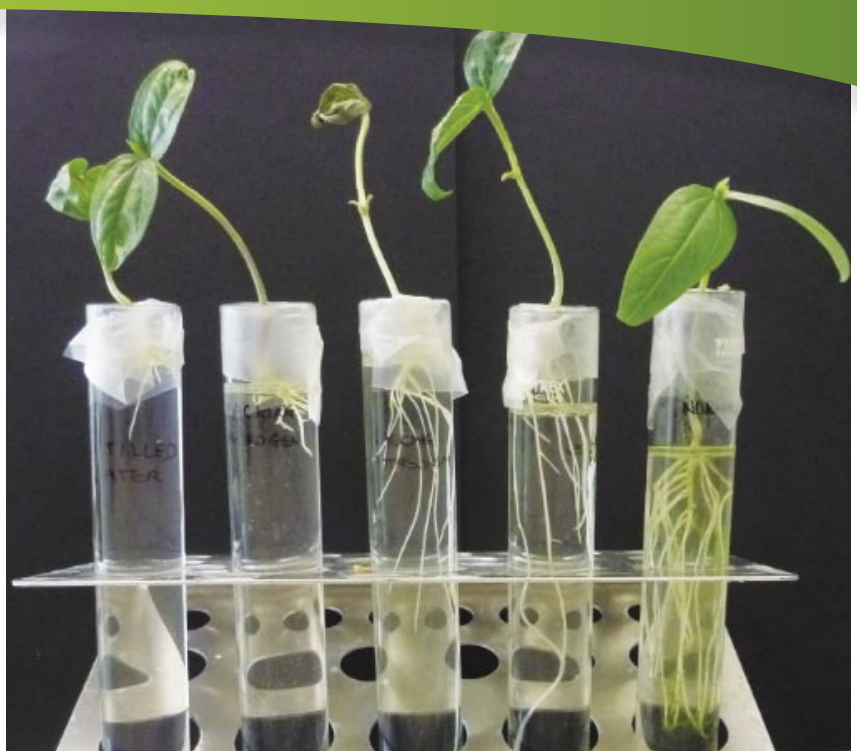


Figure 3 *- Mung bean seedlings growing in a range of nutrient solutions. From left to right the tubes shown are:*
- *distilled water;*
- *lacking P;*
- *lacking N;*
- *lacking K;*
- *standard Sach's solution.*

Preparation

Two days prior to setting up the investigation with culture solutions, place the mung beans in a flat dish, or tray. Each student (or group) will need 5 seedlings, so use enough beans to allow for the failure of some to germinate successfully. Moisten the beans (without soaking them) and cover loosely with muslin, or something similar, which will allow air to circulate. Place in a warm place for 1-2 days. Once small radicles (roots) appear the seedlings should be gently tipped onto paper towels. Students should select 5 seedlings that are at a similar stage of development.

Setting up the investigation

Materials

- 5 boiling tubes;
- test tube rack;
- Parafilm™ (or foil);
- scissors;
- marker pen;
- 5 germinated mung beans;
- a bright light source;
- a range of Sach's solutions (available from *Scientific & Chemical, Philip Harris, Timstar* etc.):
  - complete culture;
  - culture lacking nitrogen (-N);
  - culture lacking phosphorous (-P);
  - culture lacking potassium (-K);
  - distilled water.

Method

1) Label the test tubes with type of culture medium.
2) Fill each test tube with corresponding culture medium.
3) Cover each test tube with Parafilm™ (or foil).
4) Gently push down the centre of the Parafilm™ (or foil) in each test tube to make an upside down cone shape which will act as a 'well' so that the culture medium can be easily topped up.
5) Make a little hole in the centre of each well.
6) Carefully place a mung bean seed into each well and gently push the radicle through the hole into the culture medium. The seed should be on top of the Parafilm™ (or foil) and the radicle will be dipping into the liquid below. Top up with culture medium if necessary.
7) Place the test tubes in a rack and leave under bright light.

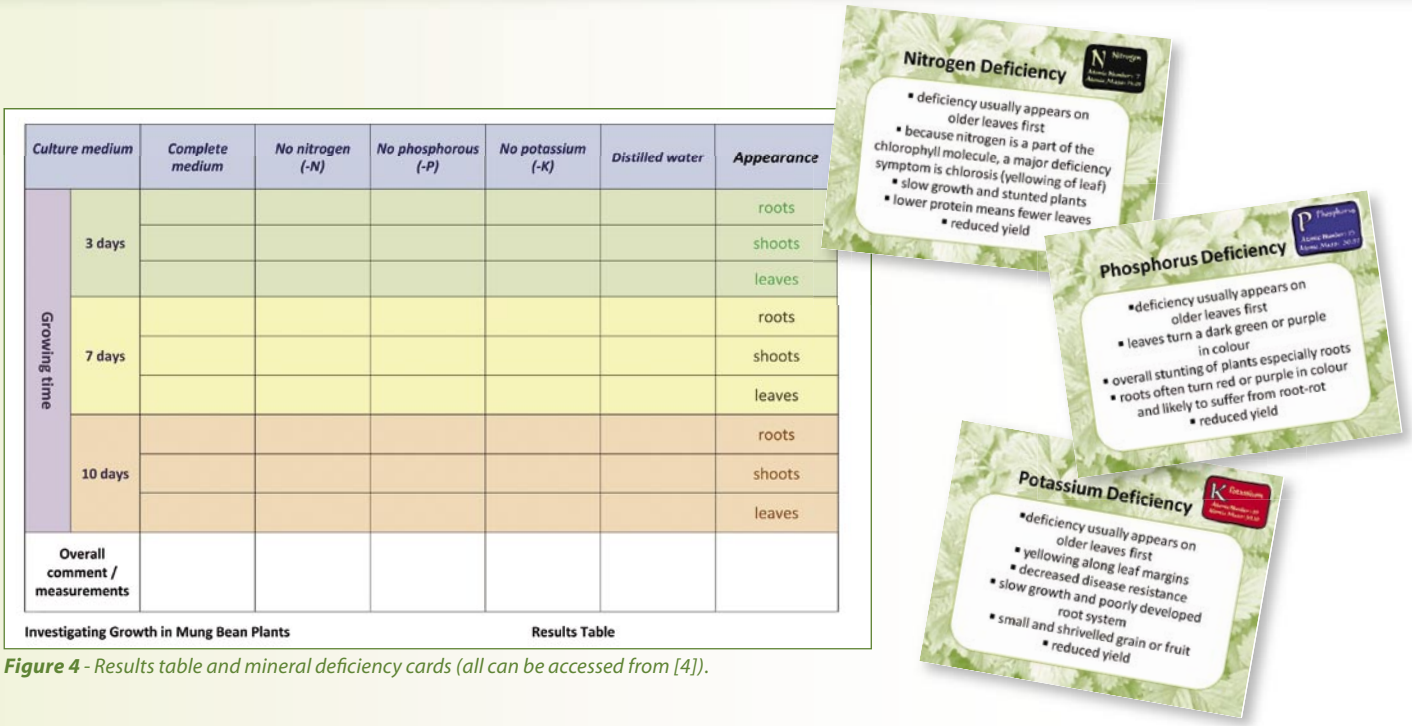


Figure 4 *- Results table and mineral deficiency cards (all can be accessed from [4]).*

Discussion

Pupils could be invited to make predictions about what might happen in relation to growth and development in each set of conditions.

Results and conclusions

The seedlings should be examined after 3, 7 and 10 days and comparisons between the growth in each culture medium can be made. A results table can be used to record results (an example table is provided (Figure 4) and is available on the SSERC website [4]).

Using the results of the investigation, together with the mineral deficiency help cards (Figure 4 & [4]), pupils can draw conclusions about mineral deficiency symptoms and why particular minerals are required for healthy growth and development.

Further suitable information can be found at http://www.allotment.org.uk/gardening/fertiliser/npk.

Additionally a pupil sheet 'Food Security and Fertilisers', provides background, questions and problem solving activities will shortly be available [4].

Discussion activity - designing a fertiliser

In addition to the practical activity we have created a discussion activity to support this aspect of the curriculum. The activity comprises a set of cards with characters and scenarios giving learners a context to help them to understand more about the decisions which have to be made when designing a fertiliser. Each scenario ends with a task to complete in small groups. There is a suggested website for each character/problem where learners might carry out further research. The activity highlights the idea that fertilisers are customised and that 'designing a fertiliser' to maximise crop production is complicated and depends on many factors. The activity introduces learners to Fred (the Scottish farmer) Risa (the Indonesian rice farmer) and Hermione (the horticulturalist); 3 story lines in the form of PowerPoint files are available from the SSERC website [4]. Each of these people has a story to tell, and issues to address, regarding fertiliser and other choices. The learners read the stories, use the background information, discuss the options and then offer advice to Fred, Risa and Hermione. The aim of the stories is to introduce learners to the importance of careful use of fertilisers and some of the hazards of over-use.

Figure 5 *- Sample slides from the discussion activity PowerPoint files.*

References

[1] The food security problem. Available on the Global Food Security website at http://www.foodsecurity.ac.uk/ (accessed July 12th 2013).

[2] United States Census Bureau offers a quick and easy method to view the most populous countries and areas of the world for any year between 1950 and 2050. Available at http://www.census.gov/population/international/data/idb/informationGateway.php (accessed July 15th 2013).

[3] The Royal Society (2009) Reaping the benefits: Science and the sustainable intensification of global agriculture. Available at http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2009/4294967719.pdf (accessed July 12th 2013).

[4] The SSERC website is available at www.sserc.org.uk. Please note that to access all resources on the website you will need to register and be provided with a log-on ID and password.

[5] Education Scotland (2013) Food Security - Advice and guidance for practitioners. Available at http://www.educationscotland.gov.uk/learningteachingandassessment/curriculumareas/publishedandplannedsupport/curriculumareas/sciences.asp (accessed July 12th 2013).

[6] I'm A Scientist Get me Out of Here (2013) Science Debate Kit: Food Security. A copy of the kit can be requested at http://www.debate.imascientist.org.uk/foodsecurity (accessed July 12th 2013).

[7] Time lapse software: *WebcamTimelapse* - a free tool for creating videos with a webcam. His can be downloaded to a laptop and used with the *Veho VMS - 001, 20-200 Magnification Digital Microscope*. (http://www.tnlsoftsolutions.com/timelapsehome.php). *iMotion HD* - a free *iPhone* app is available at https://itunes.apple.com/gb/app/id421365625.

[8] Education Scotland (2013) Sciences - Curriculum areas - Learning, teaching and assessment. Available at http://www.educationscotland.gov.uk/learningteachingandassessment/curriculumareas/sciences/index.asp (accessed July 16th 2013).

[9] SQA (2012). Course Unit Support Notes for new National Qualifications are available on the SQA website - http://www.sqa.org.uk/sqa/41328.html (accessed July 16th 2013).

Curriculum links

The Scottish curriculum has reflected the importance of food security by incorporating a strand in its new science courses. More detail is available in [8] and [9].

So, for example, delivery of a number of *CfE* level 2-4 outcomes would be supported by the activities described in this article:

- Through investigations and based on experimental evidence, I can explain the use of different types of chemicals in agriculture and their alternatives and can evaluate their potential impact on the world's food production - *SCN 3-03a*.
- Through investigating the nitrogen cycle and evaluating results from practical experiments, I can suggest a design for a fertiliser, taking account of its environmental impact - *SCN 4-03a*.

New National Qualifications

These activities support the following curricular statements from Biology and Chemistry:

National 4 Biology (Life on Earth):

4) *Fertiliser design and environmental impact of fertilisers*
   - Explore the use of natural and artificial fertilisers and the advantages/disadvantages of each e.g. cost, specificity, purity, NPK composition.

National 5 Biology (Life on Earth)

2) *Nitrogen in ecosystems*
   - Fertilisers supply nitrates to increase yield.

National 4 Chemistry (Chemistry in Society)

Fertilisers
- Percentage composition calculations can be related to the packaging of fertilisers.
- Design and prepare fertilisers using neutralisation reactions.
- Investigate the solubility of fertilisers and the potential environmental consequences associated with fertiliser use.
- Possible investigation into effectiveness of fertilisers: different school-made fertilisers could be compared by growing suitable plants.

Fly by wire - the ethanol rocket

The whoosh bottle, which we know and love here at SSERC, has become a standard feature in many chemistry classrooms [1]. More recently, a variation has come to light which not only shows the energy changes of the different fuels but puts that energy to use.

The version of this that appeared in a recent Education in Chemistry uses a length of guttering as a guide and fires a fizzy drinks bottle a satisfying distance [2]. Having been looking at this for a while before the EiC article was published we decided to get down to some serious development and soon decided on an important modification.

The SSERC ethanol rocket is projected along a guide cable. There are a couple of advantages of this:

- from a safety perspective, the fact you know the trajectory means it is much easier to ensure there is no risk of the rocket veering off course and hitting someone or something which it shouldn't;
- with the trajectory controlled in this way, it is easier to take good stills/video footage to allow estimates of velocity.

You will need:

- A dry 2-litre PET carbonated drinks bottle, with lid. (The bottle will either say PET or have a '1' inside the recycling triangle)
- 2 screw-in hooks or eyes (if there are no suitable fixings already).
- A length of string or wire (we have been using nylon fishing line).
- A couple of 'runners' (lengths of straw will do though the best we have found are a couple of short lengths of glass tubing).
- A cork borer/glass rod/drill to make the hole on the bottom of the bottle.
- A small bung to fit the hole you make.
- Tape (Sellotape®, masking tape etc.);
- Ethanol **(caution - flammable)**.

Figure 1 *- Glass 'runners' on the 'wire', fixed to the rocket.*

Preparation

- If there are no fixing points in place, screw the hooks/eyes into somewhere appropriate. A door frame is good for this.
- To make the runners, either cut two sections of straw or break two pieces of glass tubing, roughly 3-4 cm in length, heating the ends to smooth them.
- Slip the runners over one end of the string/wire before fixing.
- Tie the two ends of the string/wire to the hooks/eyes, making sure it is tight. This is especially important if using fishing line as the nylon is elastic and will stretch.
- Make a hole (a heated cork borer is an ideal tool for this) in the base of a 2 litre drinks bottle *ca.* 5-6 mm is a good size.
- Ensure the bottle is dry. Water in the bottle will affect the combustion, leading to disappointing effects.
- Put 0.5 to 1.0 cm^3 of ethanol (IDA or plain purple methylated spirits is quite good enough) into the bottle, insert the bung (or put the lid on depending on which hole you put the fuel in) and shake the bottle to evaporate the ethanol.
- Use the tape to fix the bottle securely to the two runners.

The launch

- Make sure everyone is standing well clear of the flight path, behind the rocket.
- Wearing eye protection, remove the bung from the bottom of the bottle and apply a flame to the opening, using a splint or a Bunsen lighter at arm's length.

The rocket will shoot along the string/wire with a dramatic hiss.

Figure 2 *- Rocket on the move.*

Disposal

If you only use 1 cm^3 (or less) there should be no significant ethanol to dispose of. If you use more, any spare ethanol can disposed of down the sink, followed by plenty of water, before firing the rocket.

Discussion

Dryness of the bottle - the other versions of this we have seen take their lead from the whoosh bottle and insist on a dry bottle. Indeed, several of the whoosh bottle protocols suggest drying for at least 24 hours. This seems to be rather over the top but a dry (or at least fairly dry) bottle works better than a wet one.

Re-use of bottles - if the bottle is showing signs of cracking (or more likely warping from the heat), replace it with a new one (they are not expensive).

If you are short of bottles and want to do a repeat fairly soon after the first rocket, make sure it is cool and blow fresh air through the bottle to remove the accumulated CO_2 that would otherwise interfere with the combustion.

Fuels - this reaction works well with ethanol, methanol and propanol. **Care** should be taken using these flammable solvents, especially with methanol as it is extremely flammable.

Curriculum links

- *CfE* - SCN 3-19a, SCN 4-19a;
- National 4 - Nature's Chemistry - Fuels;
- National 5 - Nature's Chemistry - Energy from Fuels;
- Higher (revised) - Consumer Chemistry - 1c Uses of Alcohols.

Teaching goals will vary with the audience. At its simplest level, this demonstration can show younger students how chemical reactions can release energy that we can use to do useful work, like driving an engine.

At a more advanced level it is possible to time the 'flight' of the rocket and work out its acceleration and thus the energy used. This can then be compared to the energy released in combustion.

Safety

- If this is being done with a single fuel, as a demonstration, ethanol is preferable to methanol for safety reasons as it is less flammable and less toxic. It is quite acceptable, with all due precautions, to use methanol as an alternative, looking at different fuels.
- Propanol will also work.
- The audience and demonstrator should be wearing safety glasses.
- This demonstration should **never** be attempted using a glass bottle.
- **Never** enrich the mixture with oxygen.
- Check the bottle for cracks or melting from previous demonstrations and use another bottle if there is any sign of damage.

Calculations

If you film the rocket, it is possible to do some calculations regarding its flight. You can use Tracker, a program well loved by the Physics department here, or (for the less technically minded) simply count the number of frames taken for the rocket to cross a certain distance. Video editing software that allows you to advance the footage one frame at a time is ideal for this.

Acceleration

A typical test here took 8 frames. As this camera was operating at 25 frames per seconds, that gives 8/25 of a second to cross a distance of 4.75 m, which corresponds to 0.32 seconds.

Starting with $s = ut + 1/2\ at^2$ it is simple, given that $u = 0$, to rearrange the equation to give $a = \frac{2s}{t^2}$

Putting in the figures above gives an acceleration of 121.2 ms^{-2}. This is 12.3 g!

Velocity

Using the same data as used under 'acceleration', a = v/t, which can be rearranged to give v = at

$V = 121.2 * 0.32 = 33.9\ ms^{-1}$
This is over 75 mph!

Energy

Now we have the energy, it is easy to work out the energy required to accelerate the rocket.

$E = 1/2\ mv^2$

The bottle has a mass of 46.3 g = 0.0463 kg

$E = (0.0463 \times 33.9^2) / 2$
$= 26.6\ J = 0.0266\ kJ$

Theoretical energy available

It is possible to estimate this using the bond energies (although we are making several assumptions):

In a 2 litre bottle, 400 cm^3 will be oxygen. At room temperature, an ideal gas has a volume of 24,000 cm^3 per mole. So in the bottle there are 400/24000 moles of oxygen = 0.0167 mol.

$CH_3CH_2OH + 3O_2 = 2CO_2 + 3H_2O$

Bond	Energy (kJ mol^{-1})	Number broken	Energy in (kJ mol^{-1})	Number formed	Energy released (kJ mol^{-1})	Energy released (kJ mol^{-1})
C-H	99	5	495			
C-O	85.5	1	85.5			
O-H	111	1	111	6	666	
C=O	192			4	768	
O=O	119	3	357			
			1048.5		1434	**385.5**

Table 1 *- Bond energies.*

So complete combustion, assuming all the ethanol evaporates, requires 0.0167 ÷ 3 moles of ethanol = 0.0055 mol.

This equals 0.32 cm^3; so the ethanol is in excess and, therefore, oxygen is the limiting factor.

Now look at the bond energies in Table 1.

So the theoretical energy release from the ethanol in our rocket is 385.5 x 0.0167 = 2.12 kJ

Efficiency

It is now possible to see what proportion of the chemical energy available has been used to impart acceleration to the rocket:

(0.0266 / 2.12) x 100 = 1.25%

Conclusions

Using a 'wire' to keep the rocket to a known path makes the ethanol rocket a safer classroom activity. It also facilitates easy filming which in turn can be used for some interesting cross-curricular work with the physics and maths departments.

Work with different alcohols gives the surprising result that although the energy per mole increases as you go from methanol to ethanol to propanol, the rocket performance decreases. Speed of combustion is more important in this case that the total energy released.

References

[1] Education in Chemistry, September 2009 - http://www.rsc.org/Education/EiC/issues/2009Sept/ExhibitionChemistry.asp

[2] Education in Chemistry, May 2013 - http://www.rsc.org/Education/EiC/issues/2013May/ethanol-woosh-rocket-methanol-reaction.asp

Important changes to the SSERC website

The normal procedure for logging into the SSERC website is about to change. We are moving away from the generic Member/XTZA5010 combination.

To continue being able to access www.sserc.org.uk you will need to be issued with your own username/password combination. To obtain your personalised log-in username and password combination email us at registration@sserc.org.uk.

Please make sure that you use a recognisable school email address and include your full name so that we are able to update our database.

Demonstration corner

The Belousov-Zhabotinsky reaction

Ever wondered what to do with that 'redundant' overhead projector stored away in one of your cupboards? Within the Chemistry Team at SSERC we have been looking at variants of the Belousov-Zhabotinsky reaction (an example of an oscillating chemical reaction) and the version presented here is probably best seen using an OHP and screen. In addition to your OHP, you will need [1] the following solutions:

A) $NaBrO_3$ (5 g in 100 cm^3 distilled water);
B) NaBr (10 g in 100 cm^3 distilled water);
C) Malonic acid (10 g in 100 cm^3 distilled water);
D) Sulfuric acid (6.0 mol dm^{-3}) [**corrosive**];
E) Ferroin - prepared from 1, 10 phenanthroline* ([**toxic**] 1.35 g, CAS Number 5144 89-8]), $FeSO_4$ (0.7 g) in 100 cm^3 distilled water.

[$KBrO_3$ and KBr can be used in place of the sodium salts above].

1) In a well-ventilated laboratory or fume hood, place 5.0 cm^3 of solution A into a beaker and add 1.0 cm^3 of each of solutions B, C and D. The mixture will be a yellow/brown colour because bromine is produced.
2) Stir the mixture until the yellow/brown colour completely disappears.
3) Add 2.0 cm^3 of solution E and swirl to mix. Pour the mixture into a Petri dish and place the dish on the OHP. The solution at this stage may be blue in colour and will turn red in a short period of time (over a few seconds). Gently swirl the dish to ensure through mixing and leave it to stand on the OHP.

Over the next few minutes tiny blue spots will start to appear and these will expand eventually producing a series of concentric rings. The reaction, which can be re-started at any time by gently mixing the solution, will continue for up to an hour. For those of you with steady hands try joining blue rings together by gently dragging the point of some scissors across the surface of the mixture! The images shown in Figure 1 were taken at various times after mixing.

Mechanism

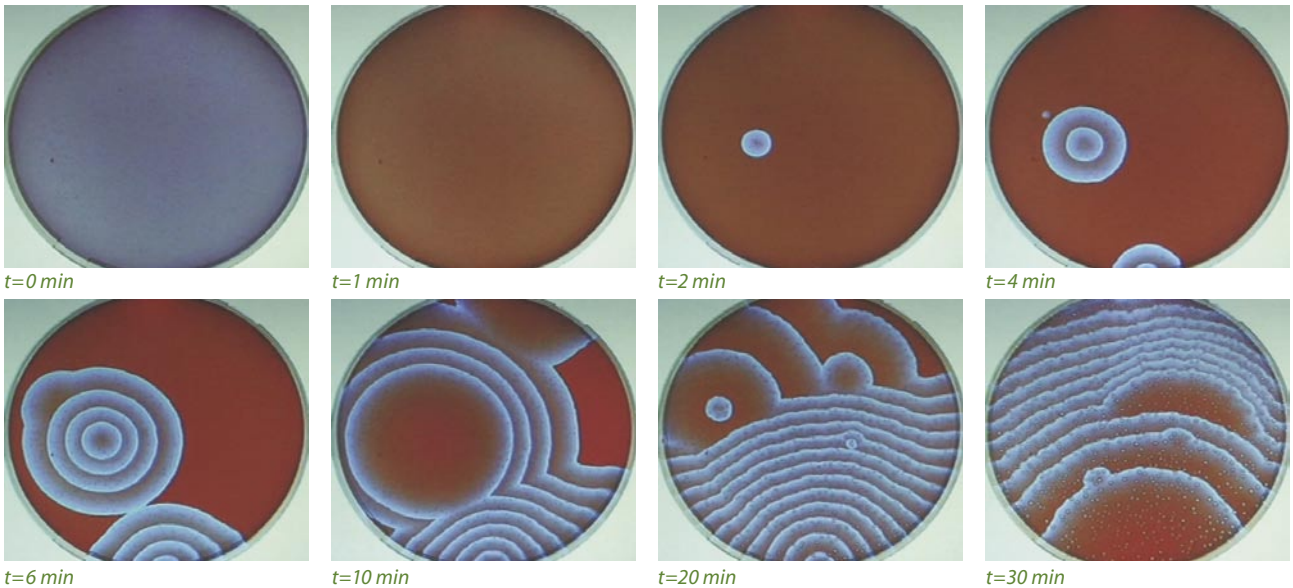
The reaction mechanism of the Belousov-Zhabotinsky is quite complex [2, 3] and the reaction mixtures for a number of variants have been published [3]. Figure 2, which has its origins in the work of Winfree [4], goes some way to summarise the overall series of reactions which is occurring.

The detailed sequence of reaction is more complex than that shown in Figure 2.

The reaction mechanisms of all known oscillating chemical reactions have at least three common features [3]:

- While the oscillations occur the chemical mixture is far from equilibrium and an energy releasing reaction occurs which drives the oscillating 'sideshow'.
- The energy-releasing reaction can follow at least two different pathways and the reaction periodically switches from one pathway to another.

Figure 1 *- Colour changes observed 0, 1, 2, 4, 6, 10, 20 and 30 minutes after mixing.*



* We use 1,10 phenanthroline monohydrate since that is what we have in stock. Because the reaction is inhibited by chloride ions it is important not to use the hydrochloride salt.

- One of the pathways produces an intermediate while another pathway consumes it and the change in concentration of the intermediate is a trigger to switch between pathways.

Summary and conclusions

An understanding of the kinetics of oscillating reactions has application in a number of different fields - some more surprising than others (for example see the link to predator/prey relations ships in [5]) and so their study is warranted for all sorts of reasons! Our advice though is to try out this interesting and intrinsically beautiful demonstration before you finally make the decision to throw away all the departmental OHPs!

Safety considerations

In addition to the cautionary statements above, solutions of phenanthroline are harmful to the environment and appropriate precautions should be taken to ensure their safe disposal.

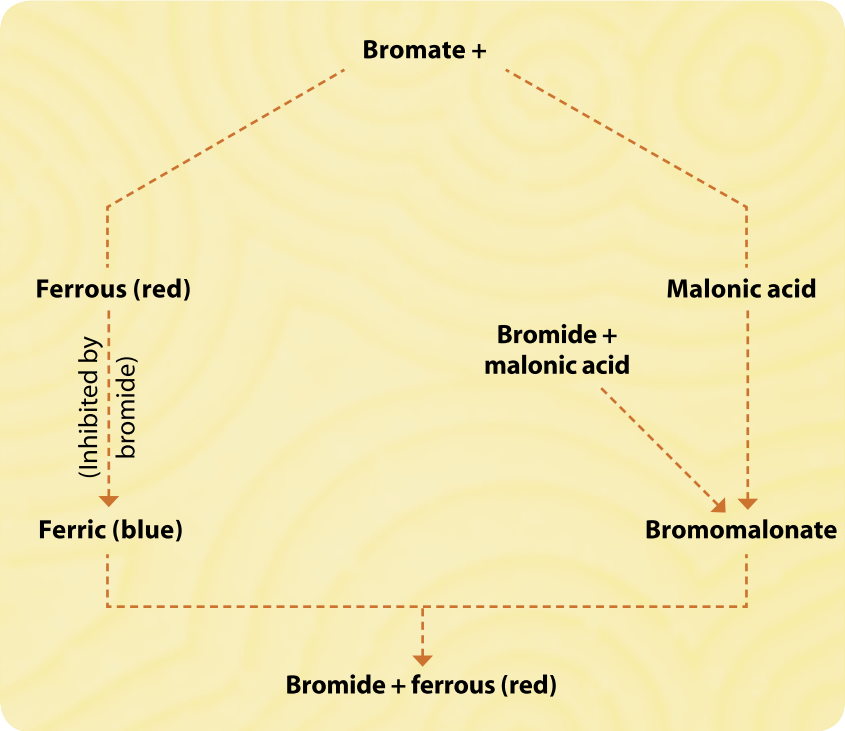


Figure 2 - *The Winfree Oscillator (see [4]).*

References

[1] Kolb, D. (1988), Oscillating reactions, *J. Chem. Educ.*, **65**, 1004.

[2] Kemsley, J. (2011), Chemical oscillations: The Belousov-Zhabotinsky reaction. Available at http://cenblog.org/the-safety-zone/2011/09/chemical-oscillations-the-belousov-zhabotinsky-reaction/ (accessed May 8th 2013).

[3] Shakhashiri, B.Z. (1985), Oscillating chemical reactions in *Chemical Demonstrations: A Handbook for Teachers of Chemistry Volume 2*, pp 232-247, University of Wisconsin Press, Madison.

[4] Walker, J. (1978), Chemical systems that oscillate between one color and another. Available at http://jesseenterprises.net/amsci/1978/07/1978-07-body.html (accessed May 8th 2013).

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Asperger's Syndrome and the school science lab

We recently had an enquiry asking for advice on supporting a pupil with Asperger's Syndrome. This is a form of autism, so we contacted the National Autistic Society [1] for advice. We recommend visiting their website for details of the condition. The society could not have been more helpful and, with permission, we have reproduced their advice here. Whilst not every piece of advice will apply to an individual pupil with AS, we hope that it will help you with the special risk assessment necessary for pupils with this syndrome.

The main thing to bear in mind is the communication needs of someone with Asperger's Syndrome (AS). Though the person may appear fluent in English they will probably take longer to process spoken language, so when asking a person with AS a question you need to keep sentences clear, simple, and short.
Slow delivery in a calm voice is advised.
People with an AS have a literal approach to language, so avoid figurative language or idioms. Give them time to process the language, before expecting an answer, e.g. count to 20 silently.

If you are addressing the whole class at once, the person with AS may not realise that they are included and should be listening unless you say their name to call their attention. This is because people with AS often find it difficult to tune in to what's important, especially if there are extraneous sounds around. It also may be hard for a person with AS to concentrate if they are troubled by or sensitive to noise, a common phenomenon in the condition.

In situations where you are giving instructions, it's always useful for the person with AS to have *written backup* of the instructions to refer to.
Many people with AS are visual learners, so using visual supports in the written backup and having visual notices in your lab is helpful too.

Step by step instructions are helpful as people with AS are not always aware of stages in a process that other people may pick up instinctively.

Some people with AS will ignore instructions that do not seem logical or necessary to them. This is obviously a problem when it comes to safety advice. It is difficult for people with AS to see or imagine the consequences of their actions; this is one of the characteristics of the condition. When giving an instruction like "wear eye protection", explain the possible consequences of not doing so.
Many people with AS observe rules they have been given meticulously, so where possible rules should be laid down and communicated in writing. Consider asking the pupil to indicate their agreement that they will follow a safety instruction, for example by ticking a check box. Don't be surprised if the person picks up on and reproaches others for not obeying the rules!

You will find some information on these links:
- Visual supports http://www.autism.org.uk/24388
- Communication http://www.autism.org.uk/18350 (mainly for parents of children)
- Organising http://www.autism.org.uk/31133

We are very grateful to the National Autistic Society for their help both in dealing with the original query and with this article.

Reference

[1] http://www.autism.org.uk

Health and safety on farm visits

A new industry code of practice *Preventing or controlling ill health from animal contact at visitor attractions* now replaces previous advice from Scottish Government, Health Protection Scotland and HSE.

Farm visits can be of significant educational value. They allow pupils to see at first hand where their food comes from (the so called 'farm to plate' message), consider issues such as care, respect and welfare of living things and to experience risk assessment in a real life setting.

Advice on Health and Safety during school visits to farms is provided by the Scottish Government [1]. However the sources of advice to which that guidance refers have now been deleted from the Scottish Government website as it has been from the Department for Environment, Food and Rural Affairs (DEFRA) and Health and Safety Executive (HSE) websites. Suitable advice on these matters is now provided by the Farming and Countryside Education (FACE) Industry Code of Practice *Preventing or controlling ill health from animal contact at visitor attractions* [2].

All animals naturally carry a range of microorganisms, some of which can be transmitted to humans, where they may cause ill health. It is uncommon for visitors to farms or other animal attractions to become ill as a result of their visit. The transmission of harmful microorganisms from animals to humans is most commonly through the hand to mouth route from contact with animal faeces or saliva. Thus the control measures to prevent transmission depend on breaking the transmission pathway by: maintaining a clean site to avoid contact with faeces, preventing contact with animals (by double fencing for example) and by effective hand washing and hygiene (Figure 1).

Where there are specific controlled areas where animals may be handled or fed, the principle control measure to prevent transmission is effective hand washing/hygiene. Here soap, running water and disposable paper towels is the preferred means of hand washing. Wipes and hand gels are **not** an acceptable substitute for proper hand washing. Young children may require close supervision or assistance during hand washing to ensure it is carried out in a hygienic manner. Young children may also require sufficient supervision to ensure they avoid hand to mouth contact while having intentional contact with animals. It should be borne in mind that *E. coli* 0157 (a microorganism that may be found in farm animals) is particularly serious in children under 5 years.

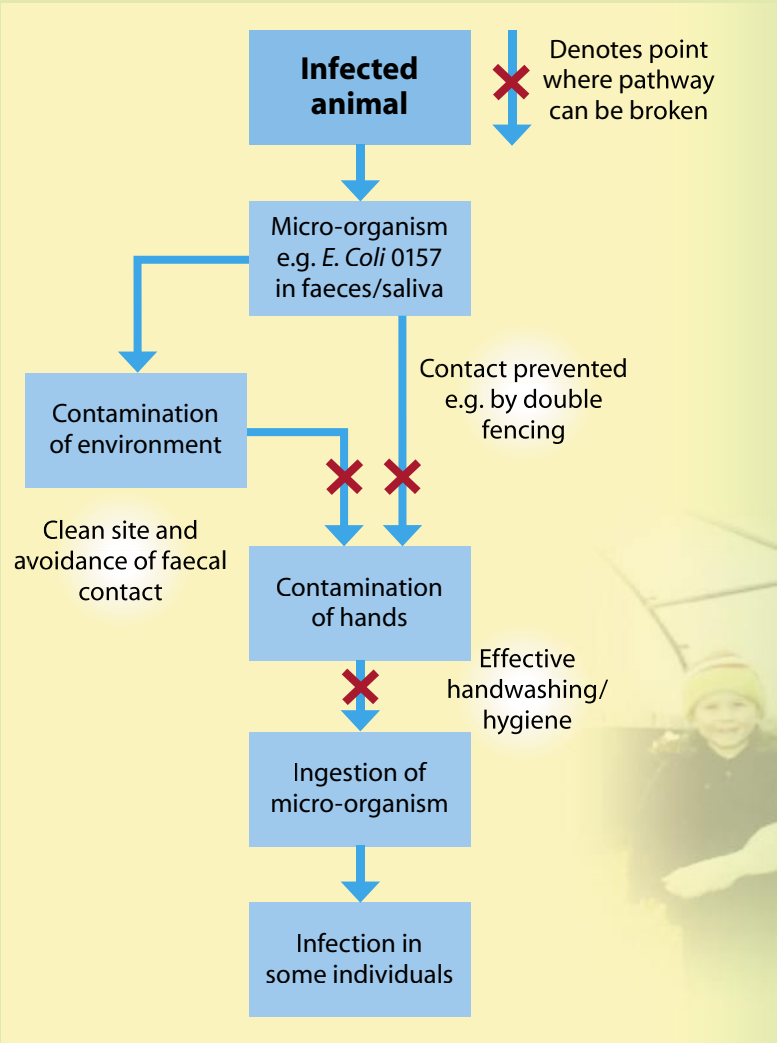

Figure 1 *- Risk pathway for microorgamisms.*

As with many other educational or recreational activities, visits can never be considered free from all risk. However, while the hazards are real, the risk of infection in children can be readily controlled by simple everyday measures. In Scotland it is wise to arrange such visits through the Royal Highland Educational Trust (RHET) Countryside Initiative Project Coordinator [3]. Even if you have a local farm happy to accommodate a school visit it would be wise to arrange for the farmer and RHET to make contact to ensure that suitable arrangements are put in place for a visit. RHET works with volunteer farmers to facilitate free, fully risk-assessed Farm Visits.

There is a shared responsibility between the farmer or visitor attraction and the visiting school for risk assessment. Although the host farm or attraction will put control measures in place, it is important that the teacher knows what they are, judge if they are suitable based on the Industry Code of Practice, and inform, instruct and supervise children so that they comply with the control measures. If a farm visit is arranged through the local RHET coordinator, a pre-visit 'walk through' of the visit will be arranged where risk assessment can be discussed along with the desired educational outcomes for the visit. Further details are available through the RHET web site [3].

Before your visit, you should:

- Read and understand the advice in the industry Code of Practice, and discuss arrangements for the visit with the management at the site.
- Confirm that the control measures provided at the site match the recommendations in the industry Code of Practice.
- Seek advice from your local authority/employer on what the appropriate ratio of pupils to teachers/adults should be.
- Discuss and agree with staff/parents/helpers their roles and responsibilities during the visit. In particular, they must understand the need to make sure that the children wash, or are helped to wash, their hands thoroughly after contacting animals and before eating.

Key points to cover with the children should include:

- Explaining the rules for the visit, stressing that they must not eat, drink or chew anything (including sweets) outside the areas in which you permit them to do so.
- Explaining why they must wash their hands thoroughly after contact with the animals, and before eating or drinking anything.
- Demonstrating how to wash their hands properly.
- Discussing the requirements for appropriate clothing, including suitable footwear. Sandals are not suitable and Wellingtons may be required (or supplied).
- Checking that cuts, grazes etc. on children's hands are covered with a waterproof dressing.

During and after the visit, make sure that the children:

- Are reminded of the rules/precautions to take upon arrival at the site.
- Do not kiss animals.
- Always wash their hands thoroughly before and after eating, after any contact with animals and again before leaving the site.
- Eat only food that they have brought with them or food for human consumption that they have bought on the premises, in designated areas.
- Never eat food that has fallen to the ground.
- Never taste animal foods.
- Do not suck fingers or put hands, pens, pencils or crayons etc. in mouths.
- Where practical and possible, clean or change their footwear before leaving. Facilities may be provided for this e.g. disinfectant footbaths.
- Wash their hands after changing their footwear.

Check that the children stay in their allocated groups during the visit, and that they:

- Do not use or pick up tools (e.g. spades and forks) or touch other work equipment unless permitted to do so by site staff.
- Do not climb on to walls, fences, gates or animal pens etc.
- Listen carefully and follow the instructions and information given by the site staff.
- Approach and handle animals quietly and gently.
- Do not chase, frighten or torment the animals.
- Do not wander off into unsupervised or prohibited areas e.g. manure heaps.

Remember the children are your responsibility during the visit:

- You should supervise them during the visit, especially during hand washing to make sure that each child washes thoroughly. Site staff may be able to help with this supervision.
- Allow plenty of time for hand washing before eating or leaving the site so that the children do not have to rush.

References

[1] Health and Safety on Educational Excursions - Farm Visits, The Scottish Government, 2004. Available at http://www.scotland.gov.uk/Publications/2004/12/20444/489523 (accessed 17th June 2013).

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Not socket science?

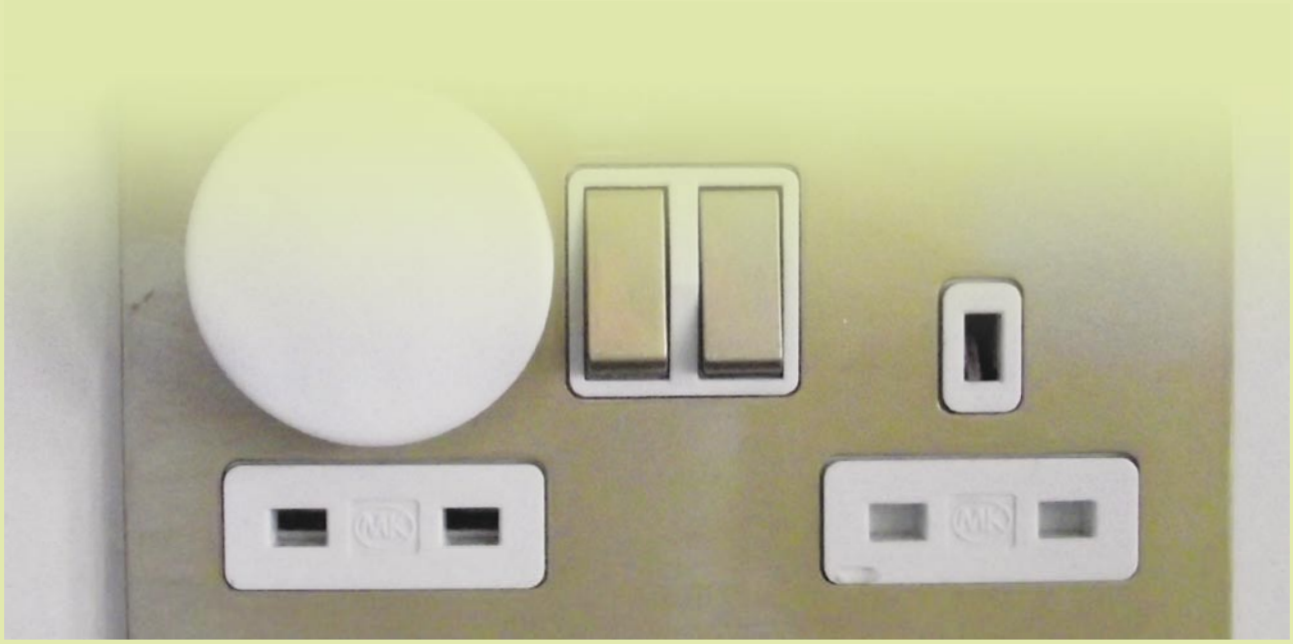

Figure 1 *- Wrongly inserted socket protector.*

Have a look at the humble UK 3 pin electrical socket. It epitomises what health and safety people call an "engineered control measure". The steps to protect people from harm are built into it - no need to rely on them putting on protective equipment, no need to rely on them behaving in a sensible manner. A UK socket does this by having the live and neutral terminals covered by a shutter that only opens when the slightly longer earth pin is inserted. This design, to BS 1363, has been around since 1947. Some recent designs need all three pins to be inserted simultaneously before the shutters will open.

We have recently heard of some educational establishments taking further precautions that they feel will make these sockets even safer, namely fitting plug-in socket covers. Is this the right thing to do? The Royal Society for the Prevention of Accidents (RoSPA) [1], after describing the safety features outlined above, has this to say, "RoSPA therefore does not consider it necessary to recommend the use of socket covers." Others think that socket covers are actually dangerous. If they are not made to the correct dimensions, they can damage the sockets. Many are flexible or brittle, leading to the situation where a child could insert the protector upside down (Figure 1), thus opening the shutters in and exposing live and neutral sockets. Similarly, if the cover snaps when a child attempts to remove it, the earth pin may remain in place, keeping the live terminal open. The website http://www.fatallyflawed.org.uk/ has a picture of a paper clip that has been inserted into the live terminal of a socket fitted with a protector.

Advocates of the covers point out that they are not solely to stop children from sticking foreign objects into sockets. They prevent a child from plugging in an iron or electric fire, for example, and burning themselves or starting a blaze. RoSPA's advice is again helpful. Unused electrical equipment should be kept out of the way of children until they are old enough to be able to use it safely. This seems like a far better control measure than socket covers which may introduce hazards of their own. As we have said before, if your employer tells you that you must carry out a particular action for reasons of health and safety, SSERC cannot over ride that advice, but we are very happy to engage with local authorities and school management/governors when their advice is at odds with our own.

Reference

[1] http://www.rospa.com/faqs/detail.aspx?faq=595 (Accessed July 2013).

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