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STEM bulletin

Supporting STEM for all Local Authorities through advice, ideas and inspiration

A chemistry map of Scotland

Ten years ago now the RSC set up a project to produce a map of sites related to Chemistry in Scotland. Sadly, this is now defunct and the web page has expired. Given the huge importance of chemistry in the history of Scotland, it seems a good idea to see about reviving the idea.

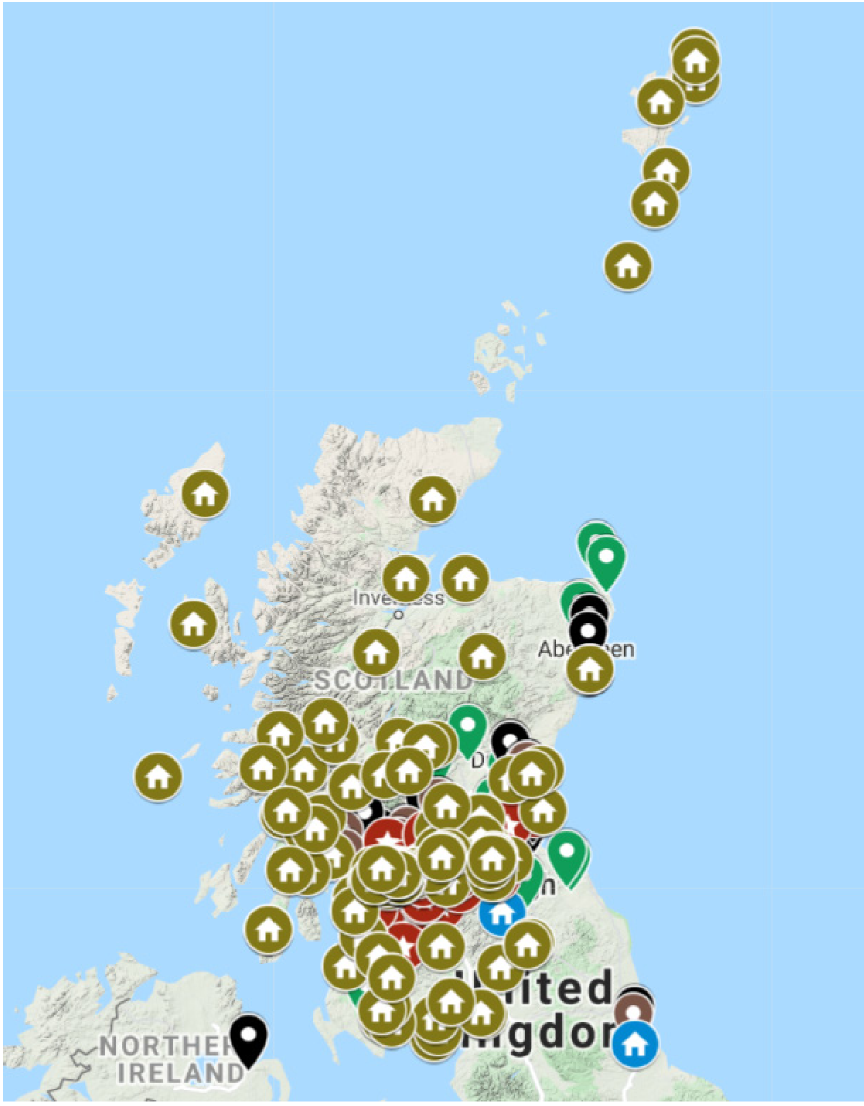
As a result, we have produced a map, on Google Maps, showing the location of a large number of sites relating to the history of chemistry in Scotland.

It includes:

- Locations where well-known Scottish Scientists were born, lived and died and where they are buried.
- Sites relating to the boom in the Shale oil industry in Scotland (mainly) in the 19th century.
- Sites of chemical-related industries from gunpowder factories through to oil refineries.
- Sites of some significant mines of metals – including a couple of Scottish gold rushes!

One element of surprise in the research has been seeing how much information has been lost – or at least is not easily available without lengthy spells in the national archives. As a result there are bound to be many omissions and inaccuracies, hopefully fewer of these. If anyone spots any of these, please get in touch so we can update the map.

So, you may be asking yourself, what is the point of all this? Aside from simple academic curiosity, we see this as a resource that could be used for cross-curricular work, particularly as part of the BGE or perhaps as a Transition project. Students can research the industries local to their school (or homes) and perhaps take part in some practical work relating to it.



You can access the embedded map via the chemistry resources page [1] or see the original on Google Maps [2].

References

[1] https://www.sserc.org.uk/subject-areas/chemistry/chemistry-resources/

[2] https://tinyurl.com/ek9ndjzk

Cognitive load theory and practical work

This article has come about as a result of a meeting at CLEAPSS with a chemistry teacher from Norfolk, David Paterson. His take on it can be found his website [1] and in an article he wrote for Education in Chemistry [2] where he said "*To understand chemistry, students need to work at three levels. These are, the macroscopic level (observations), the sub-microscopic level (particles), and the symbolic level (equations). This is known as* Johnstone's Triangle*.*

***As relative experts, teachers have internalised the differences and connections between these levels, and can easily switch between them. Students, as novices, have to contend with all three levels, often at once, without understanding the links between the ideas we are presenting. Simply put, they can find chemistry overwhelming.*"**

Cognitive Load Theory

This theory builds upon the widely accepted model of human information processing shown in Figure 2 [3] (this was published by Richard Atkinson and Richard Shiffrin in 1968.)

It describes the process as having three main parts: sensory memory, working memory and long-term memory. Since then, many researchers have added to our understanding of this concept, but the basic model remains the same.

Information is first received through our sensory memory, mainly through auditory and visual systems.

It is held there briefly until it enters our working memory.

Working memory can only handle a small number of items and for a short period of time (up to about nine for about twenty seconds).

Given this fact, it is important that the information we are trying to share with students is clear and does not contain irrelevant, 'extraneous' information.

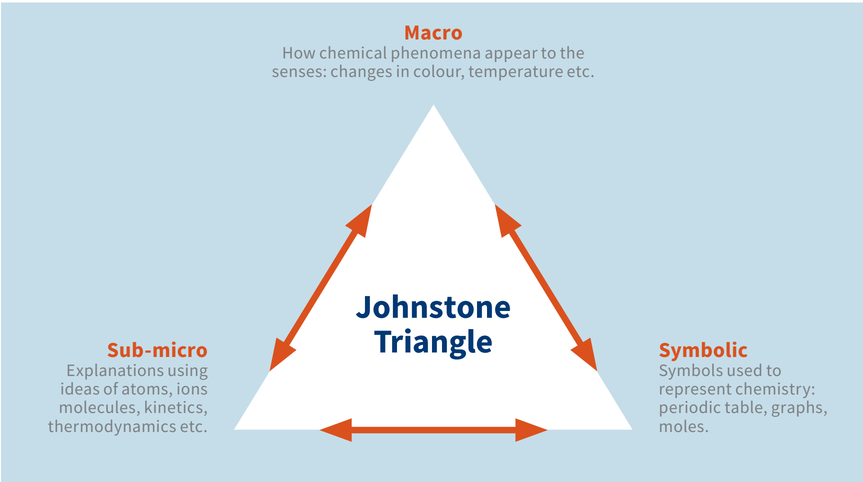


Figure 1 - Johnstone's Triangle.

The third pillar of our cognitive architecture is **long-term memory**, which is where learning takes place. The goal of teaching and learning is to pass information through these three memory types in order for students to be able to retain and transfer information in the future.

The amount of information contributes to this cognitive load. So when designing a course or lesson, you have to decide how much new information can be introduced at one time. The cognitive load is divided into three categories:

Intrinsic load – caused by the natural complexity of the information that must be processed. There is not a great deal that can be done about the task but intrinsic load is dependent on the learner's level of expertise. If something is difficult, then it is difficult but structuring tasks by using simple terminology and clear examples can help to minimize intrinsic load.

Extraneous load – Caused by irrelevant or extraneous information that gets in the way of the important bits. Keeping the message >>

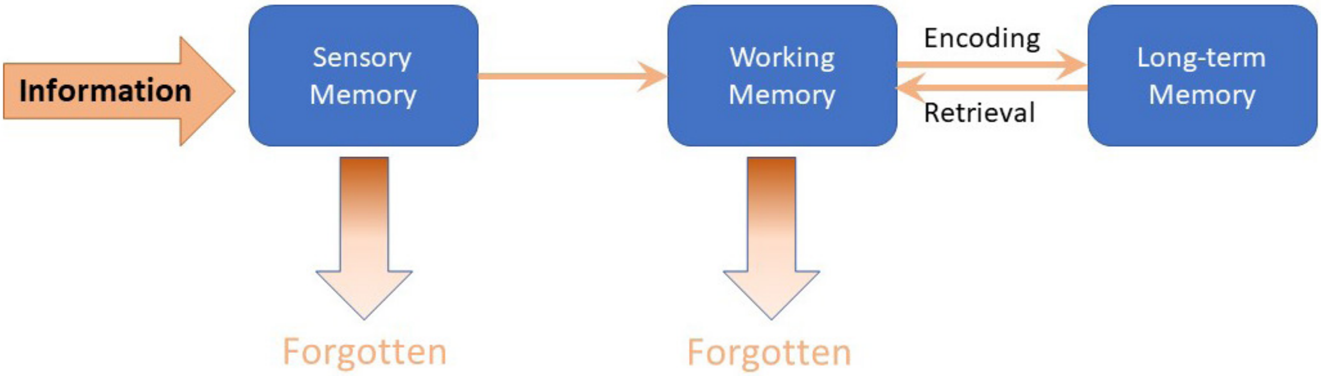


Figure 2 - Information Processing Model Adapted from Atkinson, R.C. and Shiffrin, R.M.

focused on the learning, free from distractions, allows our working memory to perform more efficiently and encourages the flow of information on to our long-term memory.

Germane load – is the work put into transferring learning to the long-term memory. This is the **effective** cognitive load: the amount of intrinsic load minus extraneous load.

Effective instructional design tries to limit the intrinsic load to what is manageable and reduce the extraneous load as far as is possible, therefore increasing germane load. The learning we want takes place via this germane cognitive load.

Further information can be found here [4].

Integrated instructions

An effective way of trying to address this problem in the context of practical work is to try to ensure that instructions are a clear as possible. David Paterson has been adapting some of the practical activities he uses with various classes to integrate the diagrams and the textual instructions into 'integrated-instructions' (he has made these available for all to use under a Creative Commons license).

Consider the following sets of instructions for the same experiment: the production of copper sulphate by neutralising sulphuric acid with copper oxide.

1) How the instructions might have appeared in a 19th century book.
(Wear eye protection) Half fill a beaker with just-boiled water.

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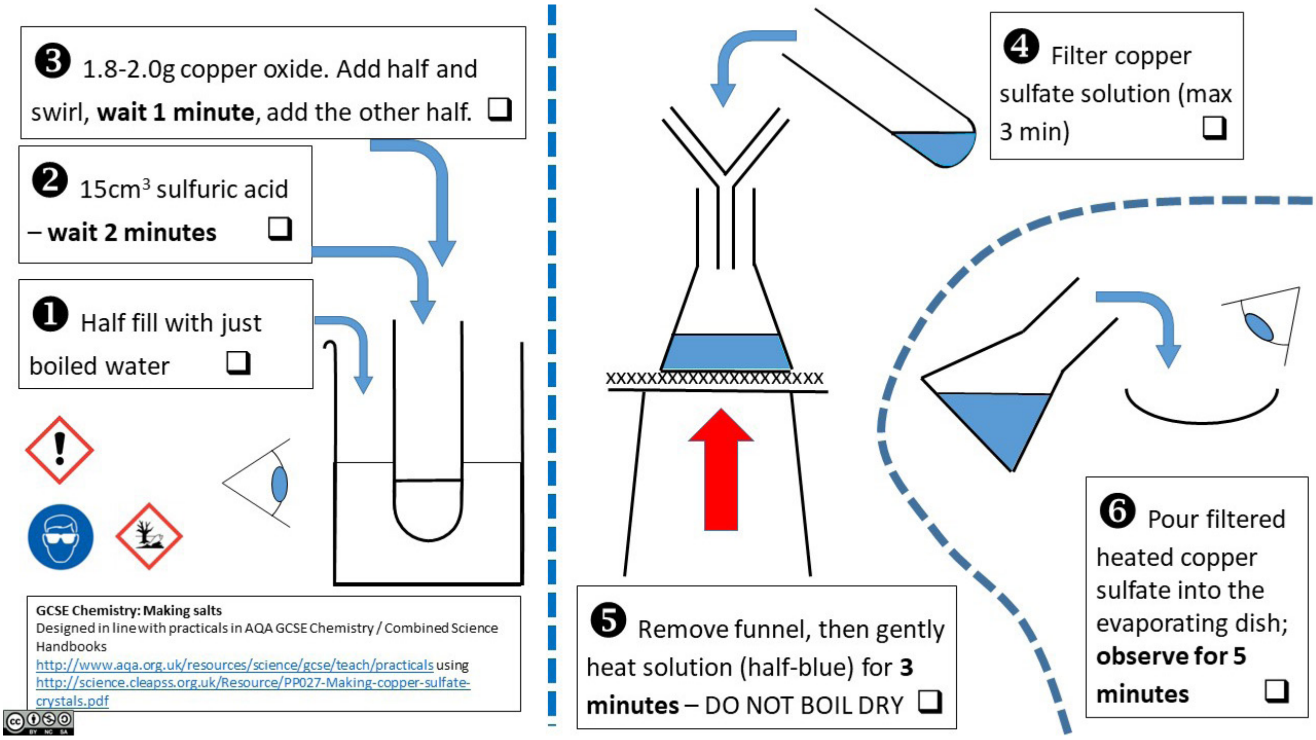


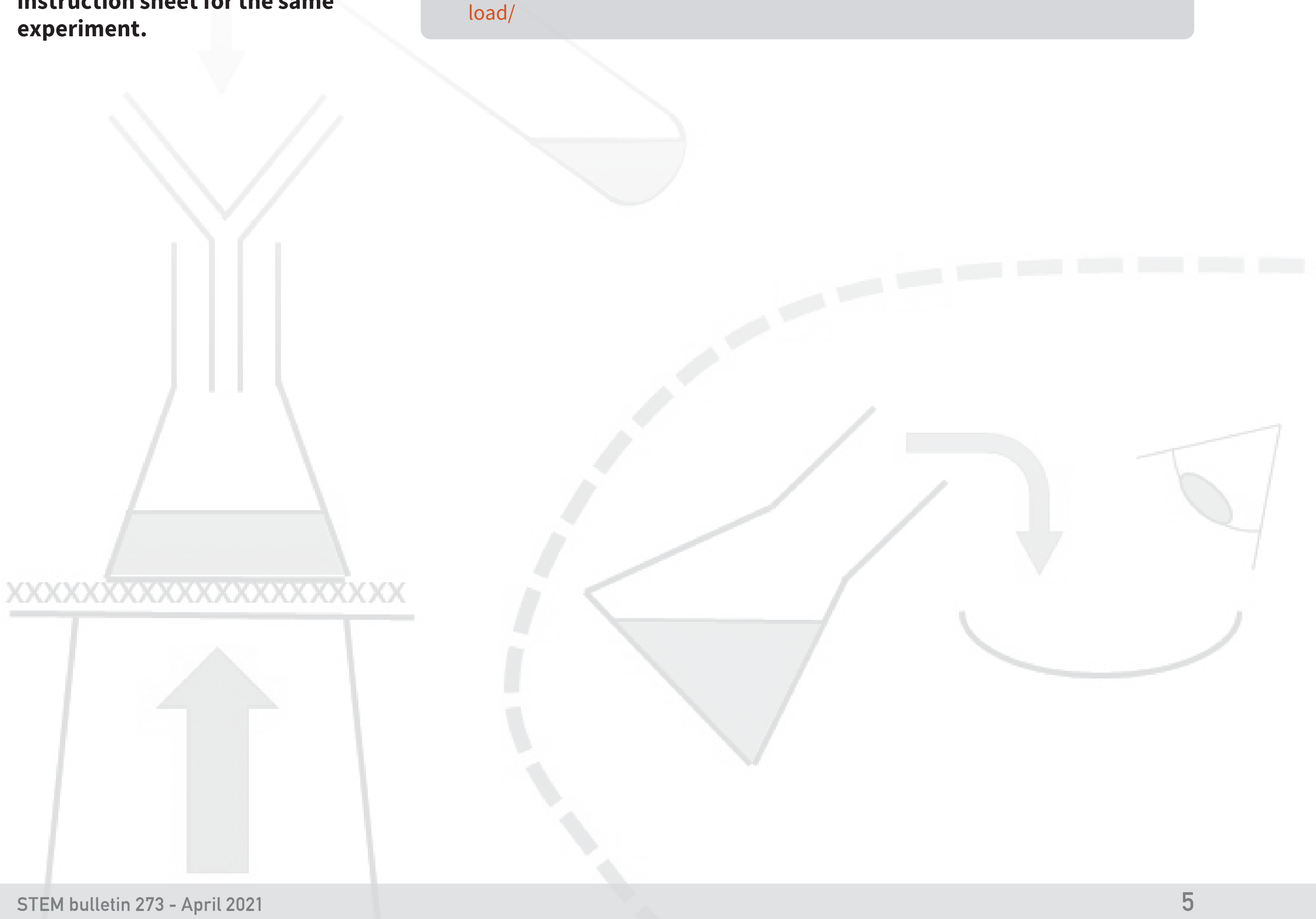
Figure 3 - An integrated instruction sheet.

Add 15 cm³ of sulphuric acid to a boiling tube and wait 2 minutes. Add 0.9-1.0 g of copper oxide, swirl to mix and wait for 1 minute. Add another 0.9-1.0 g of copper oxide. Filter the mixture into a conical flask. Gently heat the filtrate in the flask for 3 minutes. Do not boil dry. Pour the solution into an evaporating dish and observe for 5 minutes.

2) How they might appear today.

1) (wear eye protection)
2) Half fill a beaker with just-boiled water.
3) Add 15 cm³ of sulphuric acid to a boiling tube and wait 2 minutes.
4) Add 0.9-1.0 g of copper oxide, swirl to mix and wait for 1 minute.
5) Add another 0.9-1.0 g of copper oxide.
6) Filter the mixture into a conical flask.
7) Gently heat the filtrate in the flask for 3 minutes. Do not boil dry.
8) Pour the solution into an evaporating dish and observe for 5 minutes.

3) Dave Paterson's integrated instruction sheet for the same experiment.



Conclusion

As with everything in education, there is no 'one-size-fits-all' method of producing instructions that will suit all situations. But we think this approach does bear considering in at least some situations.

The use of more diagrams and less text is a great advantage for pupils with poor written language skills: pupils with dyslexia and those with English as a second language are possible examples.

For those of you who either want to reduce printing and paper usage or simply are happier with a technology-based solution, it is possible to produce an animated version of these instruction sheets just using powerpoint.

We have some examples of this sort of instruction sheet on the website [5] where you can also find an example of a powerpoint version for the experiment above (you can also find many examples on Dave Paterson's website).

This approach is applicable to other subjects as well – something we will visit in future articles. <<

References

[1] https://dave2004b.wordpress.com/
[2] https://eic.rsc.org/feature/making-practical-work-more-effective/3008027.article
[3] Atkinson, R.C. and Shiffrin, R.M. (1968). 'Human memory: A Proposed System and its Control Processes'. In Spence, K.W. and Spence, J.T. The psychology of learning and motivation, (Volume 2). New York: Academic Press. pp. 89–195.
[4] A Comparison of Three Measures of Cognitive Load: Evidence for Separable Measures of Intrinsic, Extraneous, and Germane Load. (Journal of Educational Psychology, 2008).
[5] https://www.sserc.org.uk/subject-areas/interdisciplinary-learning/cognitive-load/

Finding g using a water stream

Perhaps the first question we should ask ourselves is, 'Does the world need another experiment to find *g*, the acceleration due to gravity?' This activity is aimed at Advanced Higher, where investigations are not really about finding a physical constant. They generally involve evaluating methods. We feel that this technique is sufficiently interesting and different to earn its place.

Looking at the water stream in Figure 1, we see that the stream narrows as the water falls. Why is this?

Note that in the following discussion, we will use non-standard units of cm^3 and $cm\ s^{-1}$ for convenience. Please don't be upset.

Imagine water emerging from a tap at a rate of X $cm^3\ s^{-1}$

Suppose the water has a velocity of u $cm\ s^{-1}$

Suppose the stream has a radius of r_1 at this point

The cross sectional area A_1 of the stream is therefore πr_1^2

It follows that the volume of water per second $X = A_1 u$.

Rearranging: $u = X/A_1$

As the water streams downwards, it will speed up as it accelerates due to the force of gravity. The volume per second X will not change – if X cm^3 leaves the tap per second, X cm^3 enters the sink every second.

Suppose that at some point, the velocity of the water has increased to v.

$v = X/A_2$ where A_2 is the cross sectional area of the stream at this point.

Since v is greater than u and X has not changed, A_2 must be smaller than A_1. The stream narrows as the water travels downwards.

X can be measured by finding the time to collect a particular volume of water.

A_1 and A_2 can be found by finding the diameters of the stream at two points, then halving them to get r_1 and r_2 and using the formula for the area of a circle, $A = \pi r^2$.

u and v can then be calculated from X and A as shown above.

The vertical separation s between the two measuring points will need to be measured too.

Using the equation $v^2 = u^2 + 2as$, the acceleration a due to gravity can be found.

Making measurements

We have seen advice stating that a travelling microscope should be used to find the diameter of the stream. We have an alternative method which involves photographing the stream with a ruler alongside it. The ruler must be in the same plane as the stream.

The photograph can then be projected and measurements made. These measurements are then scaled, the scale being determined by the ruler.

Figure 1 – Water stream and ruler.

We suggest measuring the diameter of the stream at several displacements s from an arbitrary origin. Find the corresponding values of v at each point then plot a graph of v^2 versus s. This graph should be a straight line of gradient $2a$ where a is the acceleration due to gravity. See Figure 2. Note that we have not put error bars on the graph and have used large markers which, though unsuitably blobby for an Advanced Higher assignment, have been chosen for clarity for those reading this on a mobile device.

We have also used the free Tracker analysis package, most recently revisited in bulletin 272 [1] to measure diameter. Please get in touch if you would like more information on using this particular technique.

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We prefer the graphical method rather than choosing two points on the water stream. The above theory relies on the water flowing in a non-turbulent laminar manner. If the flow becomes turbulent for larger values of *s*, this manifests itself as the graph becoming non-linear. <<

References

[1] https://www.sserc.org.uk/publications/bulletins/272-spring-2021/

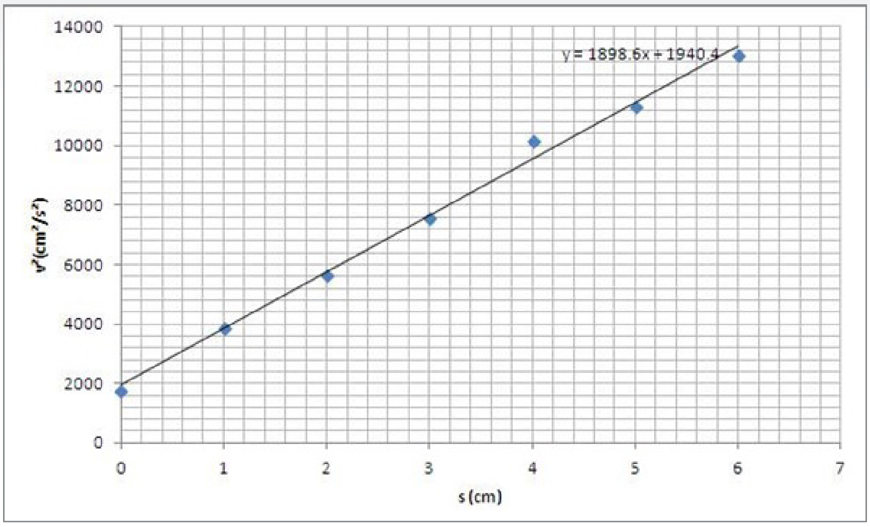

Figure 2 – graph of v^2 versus *s*.

SSERC professional learning courses

We offer professional learning events for teachers in both the primary and secondary sectors and for school technicians. Many of our events receive funding from the ENTHUSE Bursary scheme or the Scottish Government. For many courses, bursaries will help towards covering course costs and allow us to provide delegates with resources to support learning and teaching back in their schools. Face-to-face courses will take place with appropriate COVID processes and procedures in place, including social distancing.

Courses available for online booking include:

COURSE NAME	RESIDENTIAL?	DATES	CLOSING DATE	SECTOR
Welding Skills*	Face-to-face	20-21 May 2021	2 April 2021	Secondary Technology
Maintenance of Fixed Workshop Machinery	Face-to-face	25-27 May 2021	9 April 2021	Secondary Technicians
Intermediate Physics	Face-to-face	2-3 June 2021	7 May 2021	Secondary Technicians
Chemistry Summer School*	Face-to-face	9-11 June 2021	7 May 2021	Secondary Chemistry
Introductory Chemistry	Face-to-face	16-17 June 2021	14 May 2021	Secondary Technicians
Wood Turning*	Face-to-face	16-17 June 2021	7 May 2021	Secondary Technology
Safe Use Refresher	Face-to-face	22 June 2021	14 May 2021	Secondary Technicians
SSERC/IOP Online Summer School*	Online	23-24 June 2021	14 May 2021	Secondary Physics
Working with Radioactive Sources	Face-to-face	24 August 2021	11 June 2021	Secondary H & S
Safe Use of Fixed Workshop Machinery	Face-to-face	25-26 August 2021	28 May 2021	Secondary Technicians
Physics Blended Learning*	Face-to-face & Online	1-28 September & 10-11 December 2021	4 June 2021	Secondary Physics

SSERC professional learning courses continued:

COURSE NAME	RESIDENTIAL?	DATES	CLOSING DATE	SECTOR
Safe Use of Fixed Workshop Machinery	Face-to-face	1-2 September 2021	11 June 2021	Secondary Technicians
Chemical Handling	Face-to-face	7-8 September 2021	11 June 2021	Secondary Technicians
Electrical Safety and PAT	Face-to-face	9-10 September 2021	11 June 2021	Secondary Technicians
Hot & Cold Metal Forming*	Face-to-face	16-17 September 2021	13 August 2021	Secondary Technology
Environmental Science*	Face-to-face	21-22 September 2021	13 August 2021	Secondary Science
Chemistry Residential	Face-to-face	29-30 September 2021	20 August 2021	Secondary Chemistry
Safe Use of Fixed Workshop Machinery (Refresher)	Face-to-face	1 October 2021	3 September 2021	Secondary Technicians
Supporting Advanced Higher Biology*	Face-to-Face & Online	26 October & 7 December 2021	3 September 2021	Secondary Biology
Introductory Physics	Face-to-face	27-28 October 2021	10 September 2021	Secondary Technicians
Wood Turning*	Face-to-face	28-29 October 2021	3 September 2021	Secondary Technology
Safe Use of Fixed Workshop Machinery	Face-to-face	3-4 November 2021	17 September 2021	Secondary Technicians
H&S Online	Online	8, 15, 22 Nov 2021	24 September 2021	Secondary H&S
Maintenance for Fixed Workshop Machinery	Face-to-face	9-11 November 2021	24 September 2021	Secondary Technicians
Safety in Microbiology	Face-to-face	9-11 November 2021	24 September 2021	Secondary Technicians
H&S & Risk Assessment	Face-to-face	16 November 2021	24 September 2021	Secondary H&S
Intermediate Physics	Face-to-face	17-18 November 21	1 October 2021	Secondary Technicians
Hot & Cold Metal	Face-to-face	18-19 November 21	1 October 2021	Secondary Technology
Working with Radioactive Sources	Face-to-face	23 November 2021	22 October 2021	Secondary H&S
Laboratory Science Nat 5	Face-to-face	24-26 November 21	22 October 2021	Secondary Science
Safe Use of Fixed Workshop Machinery (Refresher)	Face-to-face	26 November 2021	22 October 2021	Secondary Technicians
Secondary Probationers	Face-to-face & Online	2 December 2021 2 February 2022	22 October 2021	Secondary Science
Technology Makerspace	Face-to-face	7-8 December 2021	5 November 2021	Secondary Technology

*This course attracts ENTHUSE funding which offsets the course fee.

Please check our website pages at **https://www.sserc.org.uk/professional-learning/calendar/** for the most up-to-date details on our professional learning calendar.

Courses are available for online booking at **https://www.sserc.org.uk/course-online-booking-form/**
Courses may be postponed due to the COVID-19 situation.

Keep an open mind

Whilst preparing our Bulletin article on Tracker – a truly superb open source motion analysis program – we were reminded of other great free or open source Apps that we use regularly in our mobile devices course or software that we use as part of other workshops.

During one of our recent physics professional learning courses Oliver Higgins and Matthew Smith from Glasgow University delivered a workshop based on using a smartphone, some cling film and a few drops of water to construct a simple microscope [1].

Delegates immediately recognised how useful this activity would be during lockdown as a blended learning activity. Oliver and Matthew also demonstrated a simple 3D printed structure that, with the addition of a simple glass bead, became an effective microscope. During their presentation they mentioned that in the research phase of their project they were influenced by the work done by the University of Bath with their Openflexure microscope.

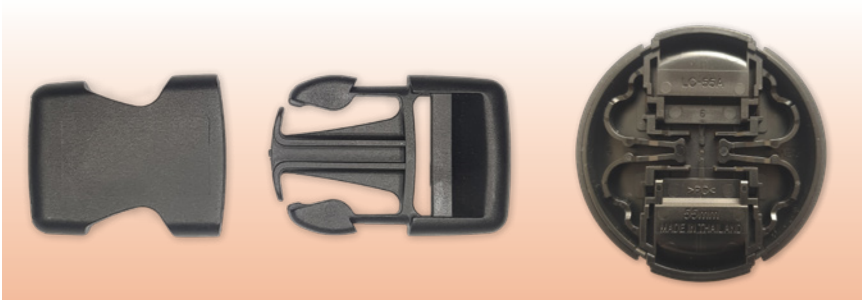

Figure 1 - Flexure buckle and lens cap.

The Openflexure microscope project led to more investigation into both flexures and Open-Source Hardware. Flexures are, at their most basic, simply thin strips of plastic or metal designed to bend, within their elastic limit, in a particular way and are commonly used in manufacturing. Typical examples are the plastic buckle and the lens cap shown in Figure 1. The buckle contains two flexure 'prongs' and the lens cap four curved flexure strips designed to act like a spring.

The definition of Open-Source Hardware, taken from Joshua M. Pearce's book *Open-Source Lab: How to Build Your Own Hardware and Reduce Research Costs* is: "tangible artefacts – machines, devices, or other physical things – whose design has been released to the public in such a way that anyone can make, modify, distribute, and use those things". The book from 2014 discusses benefits, cost savings, licensing, building a "Rep Rap" machine (3D printer), microcontrollers as well as giving construction details for several items of lab equipment.

A video of Dr Joshua Pearce talking about open source hardware can be seen on youtube [2].

We had already, coincidently, constructed the Geiger kit (Figure 2) referenced in the book and had used our 3D printer to make test-tube

Figure 2 - Geiger counter.

Figure 3 - Test tube rack.

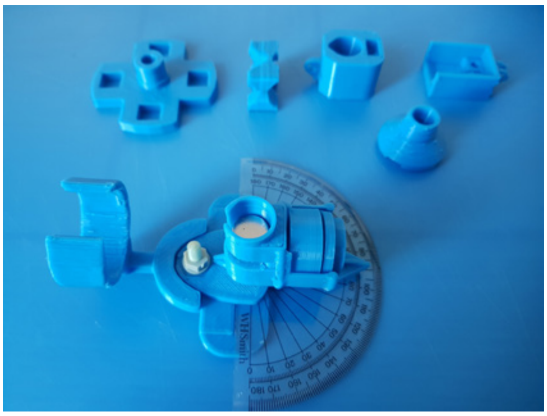

Figure 4 - Beta particle spectrometer.

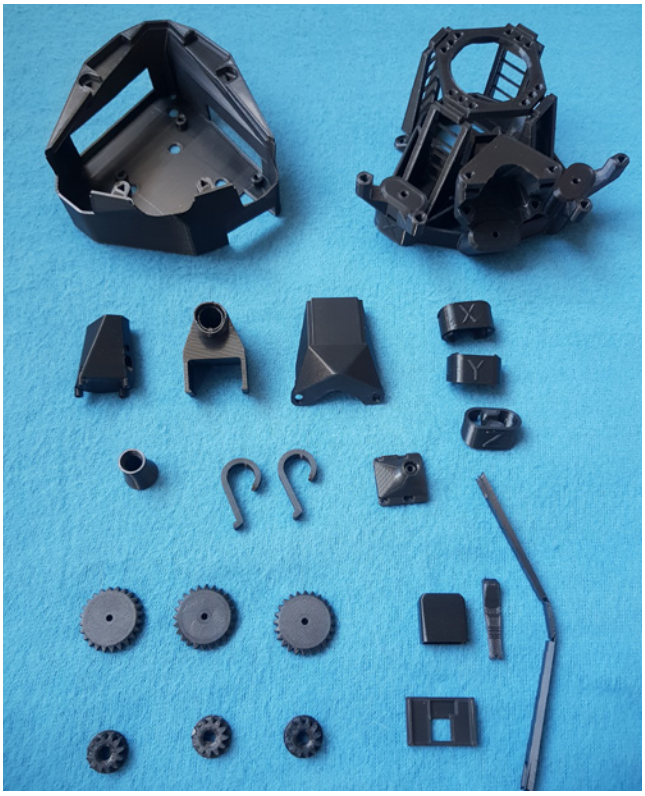

Figure 5 - 3D printed parts.

Figure 6 - The Raspberry Pi, Pi camera and Arduino Nano.

racks (Figure 3) and to make a beta particle spectrometer [3] for our Vernier Go-Direct radiation monitor Figure 4.

It was thought that constructing an Openflexure microscope would make an ideal IDL project for a STEM club and would follow on from the work done by Oliver Higgins and Matthew Smith at Glasgow University. It would also provide something new to microscope use in the classroom and provide features not readily available in traditional school microscopes for example auto-focussing, the ability to automatically stitch images together to form one large high resolution image and computer control of the microscope including over a network.

So we firstly printed the 3D parts and tools (Figure 5) and acquired the hardware: Arduino Nano, Raspberry Pi 4 2GB, Pi camera v2, Viton (a synthetic rubber and fluoropolymer elastomer) bands and three stepper motors (a DC motor designed to rotate a small fraction of a revolution on each command rather than continuously) and associated driver boards (Figure 6). Some nuts and bolts and a white LED and resistor were also needed. A kit of the 3D printed parts and a nuts and bolts kit can also be purchased from [4]. A small discount on the 3D printed parts can be obtained using the code SSERC21 at the checkout.

The microscope is easy to customize. Different parts are available to 3D print depending on whether you wish to use a Raspberry Pi camera lens or a microscope objective lens or whether you wish to use transmitted or reflected light. We chose a basic set up to prove the principle. Configuration, download links and build Instructions can be found at [5].

The downloaded image (copy of the software) for the Raspberry Pi was written to a microSD card and the programme (sketch) for the Arduino Nano was loaded onto the board.

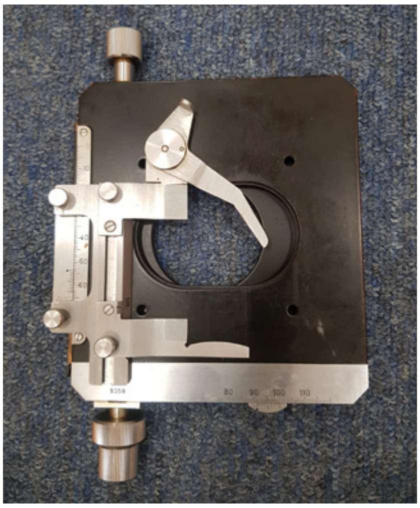

Figure 7 - Traditional slide movement.

Figure 8 - Close-up of two flexures.

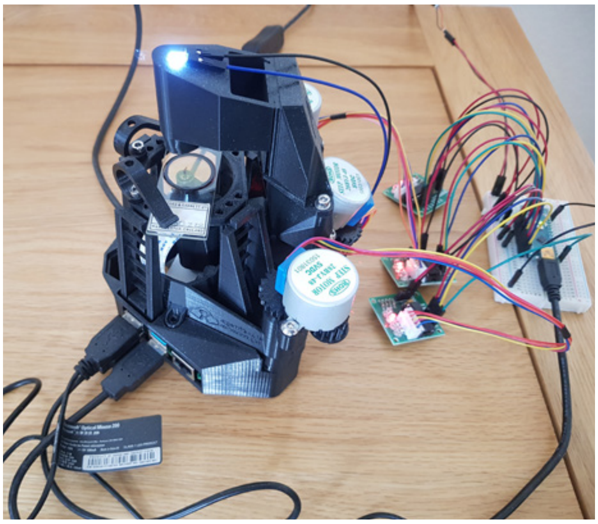

Figure 9 - The Openflexure microscope (Stepper motor driver boards and Arduino Nano uncased).

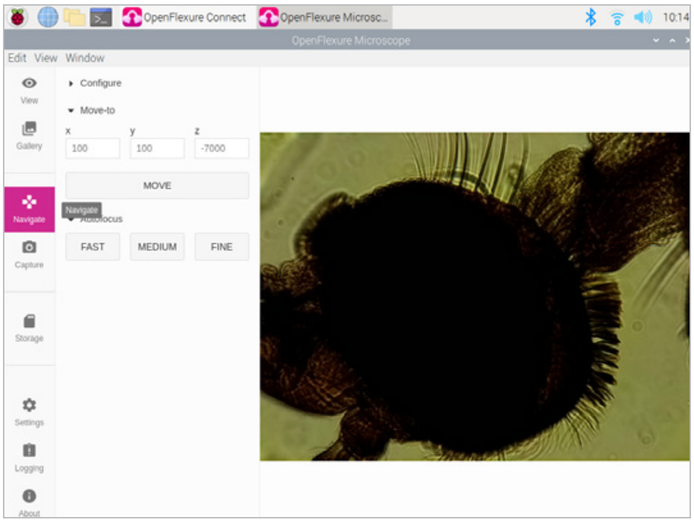

Figure 10 - The Openflexure control software.

A computer monitor, mouse and keyboard were borrowed for the initial set-up.

The microscope was then constructed following the instructions on the website above.

Moving a microscope slide a small precise distance on a microscope stage typically involves a manually operated, screw driven mechanism with a Vernier scale as shown in Figure 7. The Open flexure microscope achieves this electrically using a stepper motor, an M3 nut and bolt and flexures (Figure 8) for both X and Y axis movement.

Firmware

Sitting between software and hardware we have firmware. Traditionally hardware devices, such as soldering irons, may now come with freely available firmware. The firmware on the MiniwareTS100 soldering iron (Figures 9 & 10) allows you to set various temperatures, timings and low voltage cut off levels. 3rd party, open-source, versions of the firmware are available with enhanced features that for example allow for automatic rotation of the LCD screen, allow for a cut-off voltage to suit a wider range of battery chemistries or a temporary temperature increase. Updating firmware is usually just a matter of downloading a file to your computer and executing it with the device plugged in or just copying the updated file to the device. <<

References

[1] https://oliverhiggins93.github.io/macrophotographyworkshop/refraction/index.html
[2] https://www.youtube.com/watch?v=kBz1Z-V2ps4
[3] https://www.vernier.com/vernier-ideas/an-inexpensive-beta-radiation-spectrometer/
[4] https://openflexure-industries.square.site/
[5] https://openflexure.org/projects/microscope/build

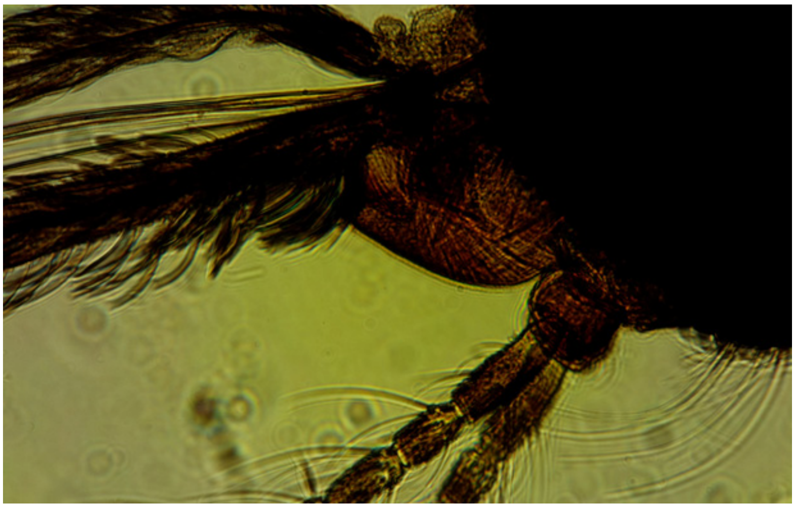

Figure 11 - An image from the microscope. Mosquito x13. Resolution 1.5μm.

Figure 12 - The Miniware TS100.

Figure 13 - Soldering Iron with firmware v2.18.

Woodturning - part 1

The art of woodturning is a process which has had a place in both the commercial and hobbyist market for a great many years. It has also been a key topic covered within the Technology curriculum whether it be at SQA qualification level or within the broad general education levels.

Figure 1

Woodturning is used in various forms in making furniture and furniture parts, building trim, tool parts, toys, athletics apparatus, and many other useful and beautiful articles in common use.

To assist in the knowledge of basic woodturning techniques, we have been working at SSERC to put in place a 2-day woodturning course for teachers and technicians. Over the last year, the Technology team have created a new workshop area, refurbished and installed 5 woodturning lathes complete with extraction and new tooling. We will be running this new course in June, for further information and to apply for a space, check out our website under the Technology PL link. In the meantime, we have put together a series of short articles as a guide covering the equipment, safety, tools, and processes used in woodturning. We will look at each area in turn over the next few bulletins.

Woodturning lathe

A woodturning lathe is a machine that holds and rotates timber against handheld cutting tools to produce cylindrical or moulded shapes. The main parts of the lathe can be found in Figure 1 with an outline description below. The size of any lathe is specified by the two main factors that determine its capability; the maximum distance between the centres and the height of the spindle centre above the lathe bed.

Bed

The bed of the lathe is made from cast iron and it supports the headstock, tailstock, tool rest and various accessories. The bed is accurately machined on its top and side surfaces and bolted to the headstock and stand.

Headstock

The headstock, made from cast iron, contains the motor, switching, speed pulleys and driving mandrel to which faceplates or other attachments can be screwed or morse taper attachments housed. On older style lathes such as in figure one, the speed of the mandrel is determined through a pulley setup. In this case a set of pulleys, which allow four different spindle speeds of 425, 800, 1400 and 2300 (rev/min). In newer machines now found in some schools, the speed is controlled via a Variable Frequency Inverter. This does give a few benefits to the user such as more incremental control of speed and soft starting and stopping.

Generally, the larger the diameter of wood being turned, the slower the speed required. For example, up to 50 mm diameter use 1400-2300 rev/min; 50 to 100 mm diameter use 800-1400 rev/min.

Tailstock

The tailstock is made from cast iron and is machined to fit the bed of the lathe. It serves two functions (1) to support the material being turned via a cone shaped centre and (2) to allow drilling holes in material either using a tapered shanked drill fitted to into the spindle or using a hollow centre to allow a drill to be passed through.

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The tailstock is designed to move along the length of the bed and locked into any position. The handwheel allows for final adjustment with a locking screw to retain in position.

Tool rest

The tool rest is made up of two parts, the main body which goes across the bed of the lathe and the tee rests which fit into the main body. These 2 component parts when assembled allow for adjustment in four directions. It can be moved along the length of the bed and locked in any position, the height can be adjusted up or down and at any angle to suit the various cutting tools being used.

Types of woodturning

Face plate

Articles such as bowls, circular bread boards, bases for lamp stands etc. are turned using face plates. The material being turned is attached to a face plate and the face plate is then attached to the headstock via the threaded end of the spindle. There are numerous types of face plates available and ways to mount the material being turned on the headstock spindle. More details of this will be given in future articles. Please see Figure 2.

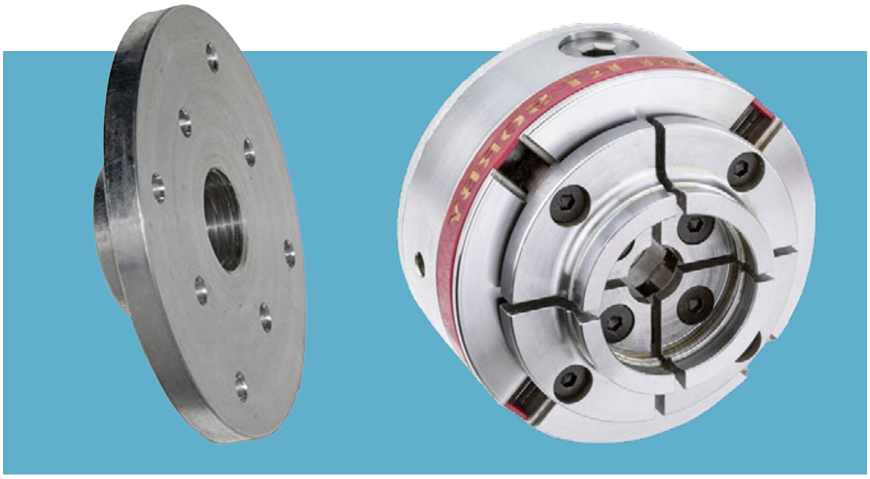

Figure 2 - Typical face plate and lathe chuck.

Turning between centres

Turning between centres, or spindle turning, is almost self-explanatory. The work to be turned (often called the stock) is fitted between the headstock and the tailstock. Table lampstands, rolling pins, stool and table legs are some examples of turning between centres. Most of these turned shapes are formed by the paring action of turning gouges and chisels. Figure 3 show the basic stages in preparing a piece of material for turning between centres.

Safety in woodturning

Safety, as with all activities undertaken in the workshop is paramount. As outlined in BS 4163, the following must be followed specifically to woodturning;

- The main controls for setting the machine on and off should be via a starter switch that has both overload protection and have a no volt release feature.
- The machine should be provided with a means of electrical isolation using a fused isolating switch which should be in the 'off' position before setting up the lathe. The main controls for setting the machine on and off should be via a starter switch that has both overload protection and have a no volt release feature.
- An emergency stop switch should be positioned so that it is readily accessible. Any guarding to the motor, pulley, spindle shafts and electrics should be locked and any access allowable with the use of a tool. Interlocking switches are also advisable.
- There should be enough clear space around the lathe to prevent the user being accidentally pushed by passers-by.
- The floor surface should not be slippery and should be kept free of loose items and wood shavings.
- Only one person at a time should operate the machine.
- Suitable eye protection must be used while operating the machine. Substantial footwear should be worn.

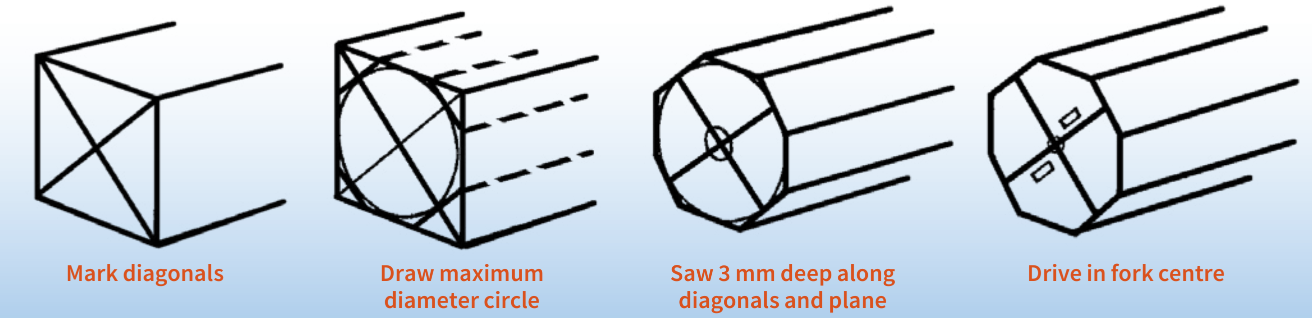

Figure 3

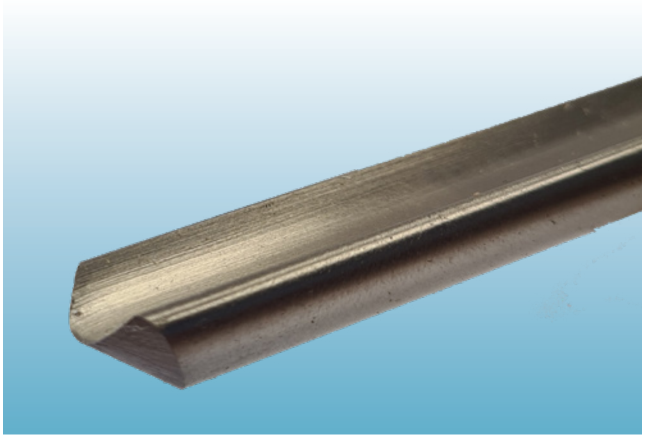

Figure 4 - Roughing gouge.

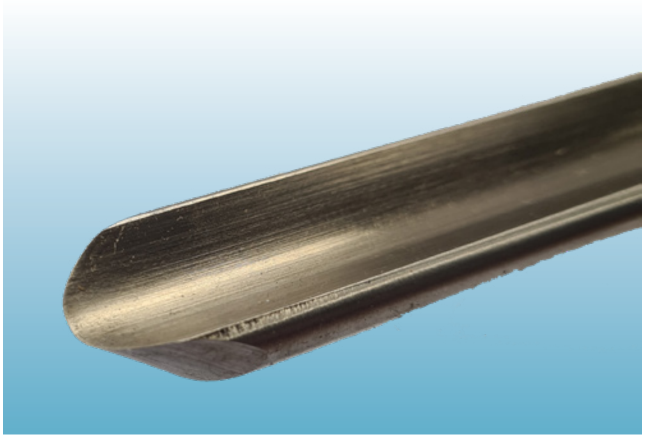

Figure 5 - Bowl gouge.

- Long hair, loose clothing and jewellery should be secured/ removed to prevent it from coming into contact with moving parts
- Gloves should not be worn while operating the lathe due to the high risk of potential entrapping of fingers.
- Timber should be inspected carefully to ensure it is free from any defects and it should be prepared in a roughly circular or octagonal shape before commencing machining operations. Segmented material should not be turned. If jointed material is used (e.g. in pattern making), it should be turned under close supervision.
- Work mounted to a faceplate, a chuck or between centres should be properly secured and balanced to prevent excessive vibration.
- Ensure that the tool rest is locked and is as close as possible and parallel to material being turned. ie. stock must not foul the tool rest.
- Only one side of the headstock should be used at one time with the other end protected.
- The lathe should be isolated before speeds are changed. A safe turning speed is important and should be appropriate for the type, diameter and condition of material.
- Woodturning tools must be held securely, at the correct cutting angle, stored safely and kept in good order. Under no circumstances should improvised tools be made or used.
- All measuring, gauging or adjustments must be made with the machine stopped.
- Dust must be controlled or prevented – When effective LEV is not in place, a dust mask conforming to BS EN 149:2001+A1:2009 class FFP3 must be used.

Woodturning tools
Lathe tools can be classified under three headings; cutting tools, scraping tools and boring tools. Turning tool handles are longer than the bench chisel and gouge handles. They are shaped to give a comfortable grip and give sufficient leverage to counteract the action of the revolving timber on the tool. Here, we will look at some of the common tools used in turn.

Tools for cutting

Gouges
Gouges of the standard pattern are made in sizes ranging from 6 mm to 25 mm. Gouges are, in the main, used for roughing work, although very fine work can be carried out with the gouge when used correctly. For turning between centres roughly to size, a 25 mm gouge with a cutting edge of 45 degrees ground square across is recommended (see Figure 4).

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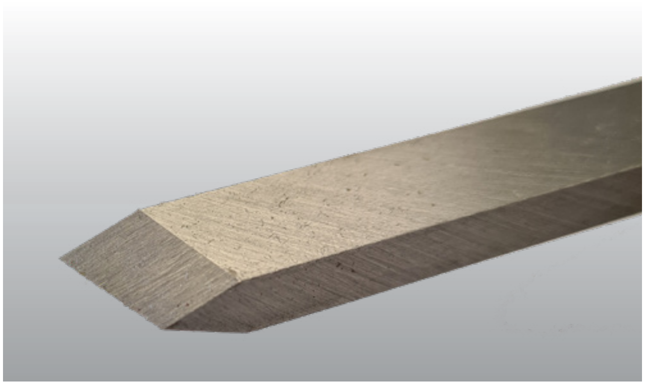

Figure 6 - Skew Chisel.

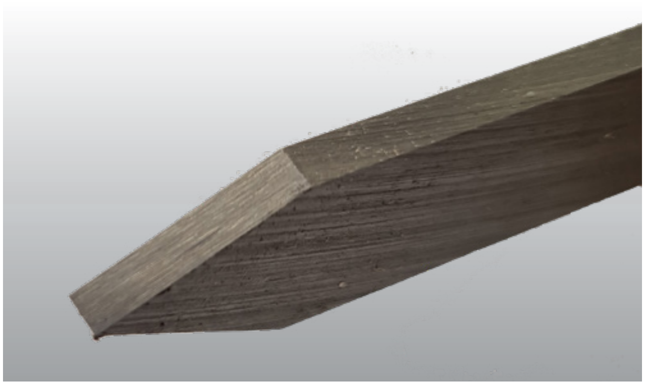

Figure 7 - Parting Chisel.

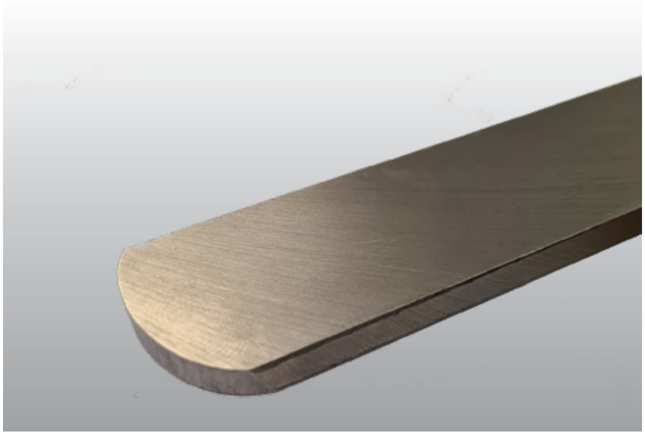

Figure 8 - Round nose scraper.

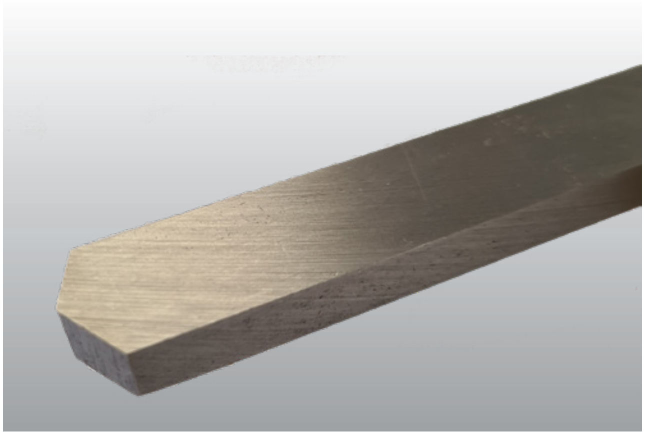

Figure 9 - Diamond point scraper.

For bowl turning, the gouge must be shaped like the end of a finger, i.e. the corners ground well back to an angle of 50-55 degrees. Like the bowl gouge (see Figure 5), the spindle gouge is shaped in the same way though the grinding angles differ – they should be ground to 35 degrees.

Chisels

Chisels are obtainable in sizes ranging from 13 mm to 25 mm and are ground on both sides. The cutting edge itself is either skewed (see Figure 6) or squared. Skew chisels are used for smoothing spindle turnings, for cutting beads and as a cutting tool is most useful for softwood turning where a scraping action would tear out the fibres of the wood. The edge should be ground to 60 degrees. Parting chisels are made in one size only. They are designed for parting off the finished job or for cutting grooves when marking out. The grinding angle for parting tools should be 25 degrees (see Figure 7).

Tools for scraping

This group of tools are those which have a scraping action. These tools are generally used for turning very hard woods. Though they produce very satisfactory results in turning hardwood generally, they are particularly suitable for use within the school workshop as they require less skill than cutting tools. They are ground on one side only and available in round nose and diamond point shapes, standard widths include 13, 19 and 25 mm (see Figure 8 and 9). Scrapers are ground to an angle of 80 degrees, with a tiny burr being raised on its top face.

Tools for boring

General purpose drilling can be done on the lathe using normal twist drills (held in a suitable chuck) or using taper shank drills fitted straight into the tailstock spindle. For boring larger holes, a Forstner bit is ideal. It can produce a clean hole with a smooth base. These are available in many sizes ranging from 6 mm to 50+ mm. To bore long holes, down the length of a spindle such as when turning table and standard lamps a Shell Auger can be used conjunction with a hollow centre fitted the tailstock (see Figure 10).

In part 2, we will look at attachments for the lathe such as centres, face plates and chucks, as well as techniques how to use some of the common tools.

Figure 10 - Selection of boring tools.

A Young STEM Leader & STEM Ambassador case study:

Inspiring women and girls in STEM at Peebles High School

Peebles High School in the Scottish Borders has been running the Young STEM Leader Programme (YSLP) for the last two years. This year, an inspiring group of Young STEM Leaders set out to tackle gender stereotypes in STEM in their school. This was achieved in a number of ways, including recruiting a variety of women STEM Ambassadors from across the UK to showcase STEM careers to fellow pupils. We interviewed the Tutor Assessors, Young STEM Leaders and STEM Ambassadors that took part to hear about the impact of the activities.

The STEM Girls group now has over 50 members. Their work has been recognised with a '20Under20 Inspire Award' from the local authority.

Iona Minto: PT STEM and Biology at Peebles High School

Iona is a Biology Teacher at Peebles High School (PHS). As Principal Teacher of STEM she aims to increase awareness, participation and aspiration of PHS pupils in STEM as well as increasing the opportunities to collaborate on STEM activities with local partners. She is a Young STEM Leader Tutor Assessor and this year took on the role of Associate Regional Trainer and Verifier for the programme.

Tell us about your Young STEM Leaders

We have 12 Young STEM Leaders, all in S6 studying a variety of STEM Advanced Highers who have achieved or are working towards the YSL6 award at SCQF Level 6. The four STEM Girls form one group within this cohort.

What made you start running the Young STEM Leader Programme (YSLP)?

I was part of the YSLP working group in the summer of 2019 and ran a YSL6 pilot in 2019-2020. I was delighted to see this feature in the Scottish Government STEM Strategy and have been impressed with all stages of the development of this programme. We ran YSL6 in the pilot last year and I was already planning to continue with the programme this year.

How are you delivering the award now?

As we don't yet have YSLP as a timetabled class we use time in the school day where my non-contact aligns with students non-contact periods. The STEM Girls meet with me every Monday – which is a great way to start the week. Restrictions in school and lockdown have posed problems, but the determination of the STEM Girls Team has meant they have still achieved a lot.

How did the STEM Girls group start?

The STEM Girls group was initiated by the girls. Ruby, Emily and Tilly achieved their YSL6 award last year via the Engineering Development Trust's Engineering Education Scheme. This was a great experience working with a local engineering company and opened their eyes to the potential opportunities in STEM.

They, along with Amber, approached me to help them establish the STEM Girls group. Their enthusiasm for STEM is infective and they are excellent role models.

What impact have the STEM Girls made to the wider school community?
The group have drawn on their own experiences and have become advocates for gender equality. They appreciate that other girls may not be as resilient as them and are passionate about improving the experience of others in the school. They recognise that gender imbalance is a local, national and international challenge in STEM and want to take positive steps to improve participation rates of women in STEM subjects and careers. For the first time at Peebles High School there is student led action to tackle such an issue.

How has the support of STEM Ambassadors been helpful to the process?
The girls have hosted STEM Ambassador Career Pathways events. They have had guest STEM Ambassadors join a Teams meeting and give a brief account of their current role and how they got there, before participating in a Q&A with the audience. Guests have included women working in Biomedical Engineering, Nuclear Energy, Data Science and Chemistry. Being able to access this amazing network has demonstrated the huge variety of roles available in STEM. The Q&A sessions allowed the girls to find out more about course choices in school, university life, working abroad and employment opportunities. The girls are keen to take up the opportunity to register themselves as STEM Ambassadors. This has shown them their value in this network and will allow them to continue their inspirational work.

Four of the STEM Girls from PHS.

Amber, Emily, Ruby and Tilly: STEM Girls and Young STEM Leaders at Peebles High School.

What is STEM Girls?
STEM Girls is a new initiative which we have set up this year at Peebles High School to try to break down gender stereotypes in STEM subjects and to create a welcoming community in which girls can develop their interest in STEM and share their ideas with others.

Tell us about the activities, events or interactions that you have run?
Our monthly 'STEM Ambassador Nights' let our girls meet inspirational women from across STEM, hear a short presentation about their career and ask lots of questions. We love these nights as they showcase the fantastic breadth of careers and opportunities in STEM and highlight that girls really can do anything! We have an Instagram account where we post about inspirational STEM Women and we run Lockdown Quiz Nights and poster competitions. We also organise Subject Support Nights and Course Choice Nights to help our girls with their STEM studies and provide support with choosing subjects for the next year.

How has being a Young STEM Leader helped you to improve your leadership skills?
We originally wanted to start up STEM Girls out of enjoyment and interest. However, along the way while working as a team to plan and run events, we have developed our communication skills by talking to and trying to build a community with the rest of the group. Our resilience has also been tested as we have tried to get everything going in the middle of a pandemic. Running STEM Girls has allowed us to try things out in a low-pressure environment which has really boosted our confidence in leadership roles. >>

What has been most inspiring about working with STEM Ambassadors?
They have all made me a lot more enthusiastic about our project and work. Attending the monthly ambassador evenings has allowed me to hear about and learn from so many inspiring women in STEM.

Esther Richter: Marie Curie Early Stage Researcher and STEM Ambassador

Esther is an Early Stage Researcher at the University of Glasgow working on droplet and acoustomicrofluidic devices for directed evolution applications. Esther has a background in biomedical engineering and design engineering and materials mechanics.

Why did you become a STEM Ambassador?
I was lucky to have family members in STEM jobs and especially my father always encouraged me to follow my interest. He also took me to STEM study & job fairs as well as to 'Girls Days' at Companies in our home region. I want to inspire and encourage students like my father did for me. STEM is very diverse, and I want to show students what my journey looked like.

Why do you think the STEM Ambassador Programme is important?
There are many opportunities in science out there and students often do not hear about them in school or they are difficult to find online. It is important to show students the diversity of STEM and show them what science can be, besides the theory taught in a classroom.

What did you think of the Peebles High School STEM Girls Group 'Career Pathways' event?
I enjoyed the interaction with the students as well as the other STEM Ambassadors. The students had interesting questions and us Ambassadors were able to answer them together and add more points to each other's answers.

Ally King: Nucleargraduate and STEM Ambassador

Ally is currently on a graduate scheme called nucleargraduates, involving short (8-month) placements around the nuclear industry. She has a degree in Chemistry from the University of Oxford. She is currently on placement in Rolls-Royce Submarines Ltd as a Chemistry Technologist focusing on analysis of radiation data.

Why did you become a STEM Ambassador?
The nucleargraduates scheme encourages us to use our experience to raise awareness about the industry and develop our professional skills. Being a STEM Ambassador allows me to inspire young people interested in STEM like myself and tell people about the nuclear industry.

Aside from the Peebles High School STEM Girls Group 'Career Pathways' event, what other STEM Ambassador activities have you been involved with?
I have produced videos and teaching tools relating to nuclear energy to help schools and homeschooling parents teach young people about the benefits and challenges my industry is facing. I hope to run in-person events at schools when it is allowed.

What did you think of the Peebles High School STEM Girls Group 'Career Pathways' event?
I really enjoyed the event! The girls were excellent hosts and asked intelligent and interesting questions. I was able to give advice I have learnt from university and my career and discuss the opportunities available to the girls. I was able to dispel myths about poor diversity at Oxford and in STEM Careers and give an honest take on my experience as a young female professional in STEM. I raised awareness about the nucleargraduates scheme. The girls' questions also encouraged a fascinating discussion about the opportunities that nuclear energy presents in the future. <<

Find out more...

STEM Leader programme

To learn more about the Young STEM Leader programme and start delivering it in your school, visit **www.youngstemleader.scot**, email us **youngstemleader@sserc.scot** or check out our Twitter **@YoungSTEMLeader**.

STEM Ambassadors in Scotland

To learn more about becoming a STEM Ambassador visit **www.stemambassadors.scot**, email us **stemambassadors@sserc.scot** or check out our Twitter **@ScotSTEMAmb**.

Radioactivity in schools - some misconceptions

Not everyone who uses radioactive sources in schools will have a physics background and some who do may still harbour misconceptions. Here are some that we have come across.

Misconception: If the corrected count rate measured from a source by a Geiger-Müller tube and counter is 10 counts per second, the source has an activity of 10 Bq

What would happen if you moved the source further away? The count rate would, of course decrease but the source can't be less radioactive and activity is a property of the source. Activity is measured in Becquerels (Bq) and 1 Bq means one nuclear disintegration per second. However, a Geiger-Müller tube window will only intercept some of the radiation emitted by a source. The further you are from the source, the less it will intercept. Think of it as being like looking at a light bulb. The closer to the bulb you are, the brighter the light seems, because your eyes are intercepting more light.

Some of the radiation emitted by the source, particularly for alpha radiation, may be absorbed by the air between the source and the Geiger-Müller tube or by the tube window itself and so not enter and be detected by the tube.

Additionally, some of the radiation that enters the tube will not be detected. Tubes may only be around 1% efficient for gamma radiation – most of the radiation passes through the tube without being detected. This is because detection relies on ionisation and gamma radiation is poor at causing ionisation. If you know the activity of your source, there's an interesting Advanced Higher project experiment to calculate detector efficiency. Please get in touch if you want to know more.

Therefore, the corrected count rate measured by a Geiger-Müller tube and counter is proportional to the actual activity of the source, dependent on a variety of factors. Although it does not give you the true activity of the source, as long as you vary only one of these factors at a time, for example introduce an absorber, it allows you to observe the effect of this.

Misconception: A leak test measures whether or not radiation is being emitted through a storage box

Most of the sources we use in schools are sealed. The definition of this is that radioactive material cannot get into the environment in normal use. The radioactive part of the source is usually in the form of a foil. The radioactive material is embedded in molten gold which then solidifies (think Maltesers in Malteser Rocky Road tray bakes). If the foil becomes damaged or deteriorates, radioactive material can be released. The leak test, described in Bulletin 263, involves swabbing the grill of a source, or its container, and using a detector to test for contamination. It has nothing to do with radiation being detected outwith a source's storage box. Any school following SSERC's guidance on storage of sources will be well within safety limits regarding radiation dose rates around the storage cabinet.

Misconception: School sources emit one kind of radiation

We tend to talk about alpha sources, beta sources and gamma sources. In reality, many radioactive materials emit more than one kind of radiation. For example, the radioactive cobalt used in school 'gamma' sources also emits beta radiation. The design is such that the beta radiation is absorbed by a piece of steel built into the source. Americium-241, which is the element commonly used to study alpha radiation, is also a gamma emitter. Since gamma radiation is more penetrating than alpha, it is impossible to engineer the source such that gamma radiation is absorbed but not alpha. The bulk of the detected radiation from the source is alpha, provided that the source is close to the detector. If the detector is more than a couple of centimetres from the source, the reading will still be above background but only gamma will be detected as the air will block all the alpha particles.

We heard a story about a student doing a crit lesson who was unaware of this. He set up his americium source and detector 10 cm apart and tried to show that alpha radiation was absorbed by a sheet of paper. Unfortunately, all the alpha radiation had already been absorbed by the air and the gamma radiation he was unknowingly detecting was singularly unimpressed by a paper absorber. Even more unfortunately, he remarked, in front of his tutor, that physicists had a saying, "When it doesn't work, it's down to friction." He barely lived to tell the tale.

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Misconception: Always use lead to shield against radiation

Lead is a good material to shield against gamma rays, though it does have to be a few centimetres thick to halve the dose you would get from a school gamma source. The trickster here is beta radiation. You can skip the next paragraph if you are not interested in the theory. Just accept that shielding beta sources with lead can result in the production of gamma rays. Perspex and aluminium are better beta shields.

The reason is due to a phenomenon called Bremsstrahlung. This is a German word that means 'braking radiation'. Beta radiation is made up of high speed electrons. A high speed electron approaching the large electron cloud of a lead atom will experience a repulsive force and slow down, i.e. it will lose kinetic energy. Where does its energy go? We know energy cannot be destroyed, only transformed to a different form. In this case, it is transformed to electromagnetic energy, namely gamma rays. Gamma rays are more penetrating than beta particles. Perspex is a polymer made of carbon, hydrogen and oxygen atoms. Like aluminium, these elements have low atomic numbers. This means that they have far fewer electrons orbiting their nuclei compared with lead. As a consequence, far less 'braking' takes place, resulting in very little gamma radiation.

Misconception: A protactinium generator is only radioactive when you shake it

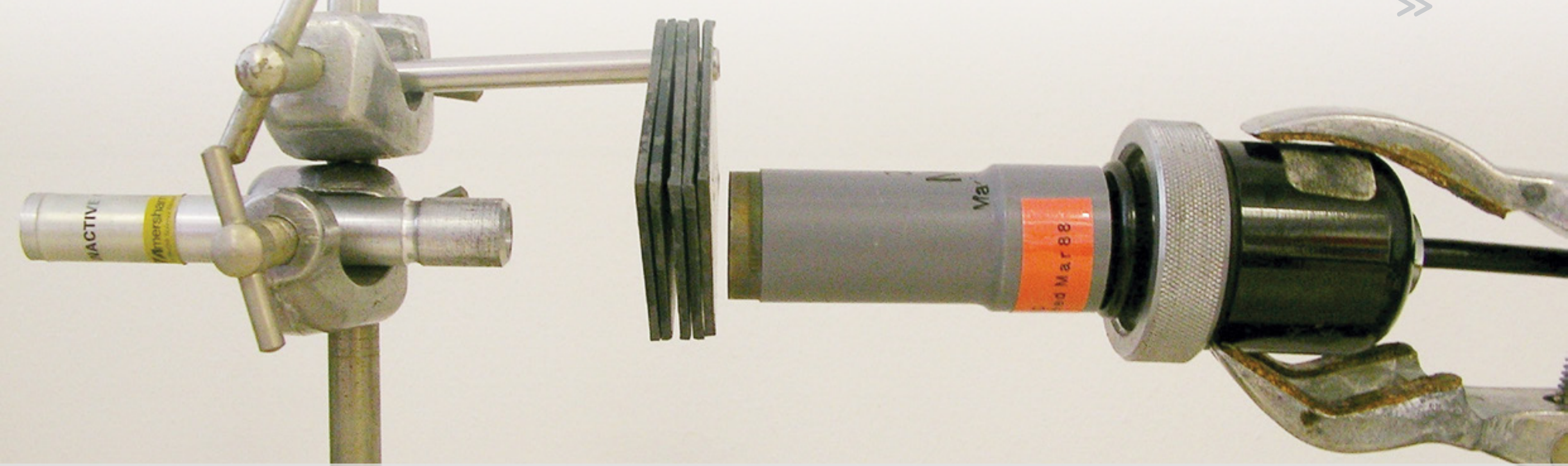
As you may know, we are not great fans of protactinium generators. Whilst they are safe and effective when used according to SSERC guidelines, they have a relatively short recommended working life (RWL) and are expensive to dispose of. We also feel that it is hard for the pupils to understand what's going on. Some teachers are not so sure either. Whilst a protactinium generator does have to be shaken before use, this is to ensure that the protactinium ends up close to the top of the container. The device is always radioactive and, being uranium-based, will not show any significant reduction in activity over its working life. The short RWL is due to the fact that aged generators can leak.

Misconception: If you put your hand in front of a radioactive source your hand will become radioactive until you clean off the radioactive particles emitted from the source

If you went to a tanning salon, the ultraviolet radiation from the tubes could give you a tan or, if you stayed under the lamp too long, could damage your skin. However, exposure to a tanning lamp would not make you personally emit ultraviolet radiation. The radiation comes from the tubes in the lamp and stops as soon as you switch the lamp off. Similarly, a radioactive source emits radiation that could also, in a large enough dose, cause harm. The radiation comes from the radioactive material in the source and although you cannot switch off the radioactive material, once the source is shielded or removed from your location you are no longer exposed to the radiation. Just like with the tanning lamp putting your hand in front of a radioactive source does not make you emit radiation and does not contaminate you with anything that makes you do so. We would of course stress that you should never direct a radioactive source at yourself or anyone else within close range because of the unnecessary dose this would result in, however if this were to unintentionally happen you will not have contaminated yourself and SSERC can be contacted if you are concerned about the level of dose you have received.

We have already talked about sealed sources. We do very little work with unsealed sources in schools so the chances of getting material on your skin that emits radiation are very small.

We think that we know where this misconception comes from. Radiation may be emitted in the form of alpha particles or beta particles from some radioactive sources. Alpha and beta particles don't **emit** radiation, they **are** the radiation. However, news reporters often talk about a 'radioactive particle' being found on a beach and here they do mean a small piece of material that emits radiation. We wish they would just say 'a small piece of radioactive material was found on a beach' but they don't.



Whilst all of the above are unarguably misconceptions, we would like to tackle another two areas where it is our opinion, rather than scientific fact, that misconceptions exist.

Working with radioactive sources is very expensive

Individual radioactive sources are expensive. Of that there is no doubt. However, most sources will last for years. There are still sources bought in the 1970s that continue to give good service in schools. If you average the cost of a source over its lifetime, costs do not look so bad.

The paperwork etc. involved in using radioactive sources in schools is time-consuming

Once you have your radioactive sources and have adapted SSERC's generic risk assessments and contingency plans, this is what you will have to do:

- Every month (apart from the summer holidays), check stock against an inventory.
- Every time that you use a source, record this in a log book.
- Leak test each source every two years (or annually for older sources – see guidance). Record the result. A leak test takes about 15 minutes per source, most of which is spent watching a timer.

Dismissing any task as trivial in terms of the time it takes is insulting to busy school staff. We do believe that the gains from experiencing practical work with radioactive sources justify the time spent on the above tasks.
For guidance on working with radioactive materials in schools, please log in to our website and visit the ionising radiation pages of our health and safety section [1]. <<

Reference

[1] https://www.sserc.org.uk/health-safety/physics-health-safety/ionising-radiation/

Home page for an art lover

There are significant hazards associated with some activities in Art and Design. SSERC welcomes health and safety enquiries from Art and Design practitioners.

Indeed much of our existing advice is appropriate to the subject. We have a number of relevant risk assessments in our Whole School and Technology sections and many of the chemicals used are in our Hazardous Chemicals pages.

What we have lacked is a web resource that makes this guidance easily accessible to teaching and support staff in Art and Design. We are delighted to report that SSERC is currently working with a representative from the National Society for Education in Art and Design to remedy this. Look out for updates in future bulletins and on our website news section. <<

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