2018

Laboratory design

A guide for schools and colleges in Scotland

Acknowledgements

The initial work on this document was carried out by Fred Young at SSERC.

Many thanks to CLEAPSS for kindly allowing us the use of the diagram of a water system on p 13.

Layout diagrams on pages 28—30 are adapted from Building Bulletin 80.

The remaining text and images were produces at SSERC by Chris Lloyd

Introduction

Whether it is a new build or a refurbishment, the development of science facilities requires a substantial investment.

No-one planning a laboratory installation can ever be entirely sure what activities might take place, particularly years into the future. Thus, it is important to ensure that the development is carried out in such a way as to provide the very best facilities for staff and students to carry out all the activities that are likely to be required by the curriculum in a manner that is safe in an environment that is comfortable and attractive.

The publication of the Science Strategy for Scotland [1] brought into focus the need for careful planning in respect of specialist science accommodation:

There is a need for investment in secondary school

science laboratories, especially in the quality of the accommodation and the equipment (including the provision of computers).

The current major investments in relation to building new schools across Scotland opens up opportunities to introduce design concepts that enhance science education as well as the more general learning experience.

The design solution must be flexible and adaptable enough to take account of both current and future needs.

The purpose of this guide is to offer advice and guidance to those concerned with the provision of science accommodation whether through new build or refurbishment of existing accommodation whilst taking into account the health and safety legislation that may apply.

1 Laboratories

The brief

There are a number of teaching activities, which are common to all the sciences. These include:

- Teacher briefings.
- Teacher demonstrations.
- Whole class activities.
- Individual and small group practical activities.
- Individual and small group non-practical activities.

Laboratories must be designed with these in mind.

Size & shape

Building Bulletin 80 [2] suggests that for lower secondary (up to National 4/5 equivalent) 60 - 73 m^2 is a suitable minimum floor area for a class of 20 students.

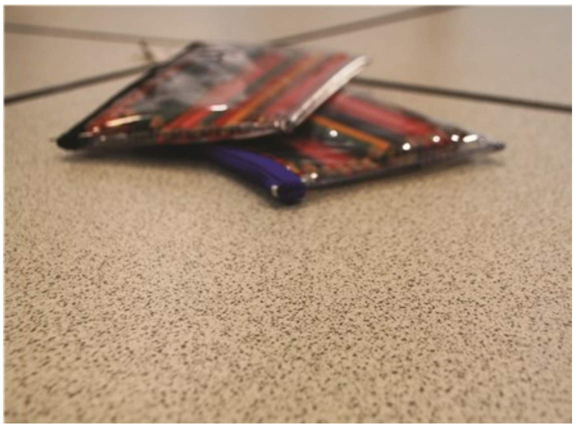
For more senior students, (Higher and Advanced Higher) 90 m^2 is more appropriate.

If it is at all possible, the larger size should be used for all the laboratories. This size should enable areas within the room to accommodate whole class activities, individual or small group practical activities and individual or small group nonpractical activities. It will also allow for the greatest flexibility in the management of the rooms.

It should be borne in mind that storage units around the walls will reduce the available area.

Area is only one aspect to consider. Shape is also important. A room that is long and narrow or that is not rectangular may need a larger area to accommodate the same number of pupils. Curved walls, while they can look attractive as a part of the overall design, can lead to added difficulty (and expense) when it comes to fittings.

As well as the physical difficulties some shapes can pose in simply fitting all the pupils in, the shape will impact on the arrangement of the tables/workstations which in turn may affect the ability of pupils to see the teacher and board/ screen.



Entrances and Exits

Contrary to popular belief, there is no **absolute** need for each laboratory to have two exits to provide adequate escape routes in the event of Fire or other emergency. The need, or otherwise, is determined by the distance from the furthest point to the door and the nature of the escape route beyond this [3].

Layout

Each laboratory will need:

- A teacher's work area / demonstration area.
- A practical area for students.
- A 'dry' work area for students.

Where the decision is taken to have separate 'wet' and 'dry' areas, care must be taken to ensure the room is large enough: such a model is much more space-intensive.

There are numerous possible layouts for benches/ work-spaces and it is up to the individual school to decide which layout works best. practical activities. It will also allow for the greatest flexibility in the management of the rooms.

It is important to ensure, however, that there is sufficient spacing between and tables/benches (see BB 80) an that visibility is optimised for all pupils: that their view of the board or demonstrations bench is, as far as possible, not blocked by classmates in front of them.

The basic choice is whether to have the services:

- On benches around the wall.
- On benches or pods more centrally in the classroom.
- A mixture of a and b.

In the case of b, do you have separate 'wet' and 'dry' areas of the classroom for practical work and written work respectively?

Some example layouts are shown and discussed in Appedix 1.

Another important point to consider is the location of these services. Some laboratories have been constructed so that no gas taps are within reach of sinks. This makes distillation and reflux all but impossible unless expensive heating mantles are used.

Benches

A working bench height of 900 mm is normal for secondary school students. Seating should be of such a height as to allow comfortable working for students when seated.

The benches should not usually be more than 600 mm deep. If they are, the gas taps and sockets should not be more than 600 mm from the front of the bench.

The needs of students with disabilities must be taken into account. (See page 10)

Bench surfaces

Resistance to water penetration, chemical attack, heat and impact are critical to work surfaces in a science laboratory.

There are various options:

1) Wood - commonly Iroko but beech and maple are sometimes used.

• Pros - relatively cheap, can be sanded down to as good as new in a refurbishment. Good resistance to water and chemicals if well sealed.

• Cons - poor resistance to heat. Seals need to be adequately maintained to ensure water/ chemical resistance. As a tropical hardwood, there are ethical issues involved. Wood from a sustainable source (perhaps recycled) can be harder or more expensive to source.

2) Synthetic (homogenous) - the main types are: cast epoxy resins, polymethacrylates and polyesters. (e.g. Corian™, Staron™, Durcon™).

• Pros - good chemical, water and heat resistance. Mottled appearance (of some) can help hide the appearance of stains. Strong, especially epoxy resins. Surface damage can be repaired.

• Cons - relatively expensive. Can be stained by some chemicals or excessive heat.

3) Synthetic (laminates) - Laminates which are on a chipboard or similar base are less suitable for laboratory use (particularly when the laminate is thin) because the layer of laminate can be damaged exposing the porous base layer. Solid laminates, however, are much more suitable. (e.g. Trespa™).

• Pros - good chemical, water and heat resistance. Cheaper than homogenous synthetics.

• Cons - Not as strong as solid synthetics. Poor resistance to heat. Damage is not easily repaired.

Floors

Flooring in school laboratories must be resistant to fire, heat, chemicals and staining. Liquids and other substances will be spilt on the floors in laboratories, so consideration must be given to slip resistance though ease of cleaning should also be considered and slip-resistant surfaces can be harder to keep clean. This could be a particular problem in some biology areas where cleanliness is important to avoid contamination in microbiological work.

If areas are set aside for electronics, anti-static flooring is recommended.

The most cost effective suitable flooring options currently available are vinyl and linoleum. Linoleum has anti-static properties and is made from renewable materials, making it a more sustainable material. Vinyl and linoleum flooring are available in both sheet and tile form. The sheet form is recommended because, although it is more difficult to repair, tiles can, and do, curl, tear and de-bond.

Both vinyl and linoleum will stain with time, so darker colours with mottled patterns are recommended.

Thick vinyls offer better sound absorption than thin ones. Vinyl and linoleum are resistant to water and most chemicals, but are easily cut and will ‘melt’ if a hot object is dropped on them. Such damage can be cut out and repaired. However, it is best to avoid the use of stools and chairs with metal legs, unless they are fitted with secure plastic end caps, as these can cause considerable damage very quickly. Even if apparently secured, they should be checked regularly.

Vinyl and linoleum flooring should be fitted part way up the walls of the laboratory to ensure that liquid spillage cannot permeate under it

Walls

Walls should have a durable and stain resistant finish and be easily cleaned e.g. eggshell paint. A light colour will assist with the provision of even illumination in the room

It would be useful if a large area of the wall is covered with pin board for display purposes. Materials will inevitably be attached to the walls and in the absence of suitable mounting boards, damage will accrue to the wall from pins, tape or blutack™ or similar

Ceilings

Ceiling type and finish should be appropriate to the use of the room. Recognition must be given to the height of the room with the possibility of fitting a suspended ceiling to assist in concealing services. The colour of the ceiling should be light in order to assist with overall light levels.

Too low a ceiling can allow temperatures to rise rapidly, when Bunsen burners are being used for example. Lower ceilings produce a lower volume in the room so ventilation will need to be at a higher level to remove harmful gases and, in addition, some experiments need higher ceilings to allow them to be performed.

In Northern Ireland, a minimum ceiling height of 2.7 m is specified for new buildings and SSERC feels that this is a suitable minimum for Scotland as well.

Lighting

Common sense dictates that a good level of illumination is required in teaching laboratories. DFES Building Bulletin 80 [4] recommends a level of illumination of 300 lux. This should be

regarded as the minimum desired level of illumination. Lighting should be arranged to allow separate control over groups of lights, such as those over whiteboards/blackboards etc.

The use of natural lighting has benefits but natural sunlight can cause problems:

- It can dazzle students.
- It can make rooms very hot.
- It can render Bunsen flames nearly invisible.
- It can make screens and interactive whiteboards very difficult to see.

The ASE publication Topics in Safety, 3rd edition [5] suggests the use of solar fi lm to help reduce these effects. However, there are a number of experiments that require the need to dim lighting in laboratories more than this would allow and we recommend the use of plastic or metal blinds (generally only physics laboratories require full black out blinds).

Sound

It is important that the sound level is not too intrusive in the classroom.

The maximum , background noise level should be the same as in any other teaching room, i.e. about 40 dB. The recommended reverberation time is between 0.5 to 0.8 s. If it is longer than this, teacher and pupils tend to speak louder to make themselves heard which makes the situation worse. Details can be found in BB 93.

Fume cupboards and other ventilation units should run at less than 65 dB (at a distance of 300 mm from the motor) so that teachers are not be tempted to switch it off if the fume cupboard motor or fan is too loud.

Ventilation

All laboratories need good ventilation to ensure that any gases, fumes or water vapour produced during experiments are diluted quickly. Topics in Safety [5] suggests that it is desirable to have 5-6 air changes an hour. (Building Bulletin 101 [6] also gives a figure of 5 changes per hour). SSERC recommends this as an adequate level of ventilation for school laboratories.

However, to ensure adequate ventilation, SSERC recommends, especially in chemistry laboratories, that extractor fans and air inlets be fitted. Care should be taken when installing the air inlets to ensure that they are located in positions that allow a good flow of air through the laboratory.

In laboratories where microbiological work takes place, it is important that ventilation can be switched off to prevent draughts

Carbon dioxide levels are required to be controlled in classrooms. The HSE guidance is that the average level over the day, measured at seated head height should be no more than 1500 ppm. In addition, the maximum peak level should be no more than 5,000 ppm. If the level is elevated, at any occupied time, the occupants should be able to reduce the level to below 1,000 ppm. In a laboratory with adequate ventilation, this will not be a problem but the mere presence of a flashing light on a panel that warns of elevated levels is not sufficient if there is no means to rectify the situation.

Where the room ventilation is incorporated as part of a larger system, it is important to have some sort of a boost or override system in the chemistry labs to allow for rapid clearing of smoke or fumes.

The position of fume cupboards in a laboratory is important as different ventilation systems affect each other. Fume cupboards should not be installed near doors or in the corners of rooms where air turbulence will affect their performance. Fume cupboards and room extractor fans should be installed on separate electrical circuits.

Some schools use a reconditioned air circulatory system. There have been problems reported of smells from one classroom being distributed to several others. Obviously, in the case of harmful emissions this could have serious implications. Such systems are best avoided.

Fire Prevention

Smoke detectors are best avoided in biology and physics laboratories and are not at all suitable for chemistry labs ans fumes generated routinely will set off the alarm on a regular basis. Heat sensors are a much better option.

Smoke detectors in corridors outside laboratories can be problematic as well. If the ventilation is insufficient then smoke escaping during normal use of the doors could result in the alarm being set off. If smoke detectors are to be installed in corridors here, care should be taken over their placement to minimise these false alarms.

Sprinkler systems are not suitable for science labs. Especially in chemistry labs, the water could cause additional hazards.

Disabled accessibility

Under the Disability and Equality Act 2010, all schools are required to provide auxiliary aids and services to disabled students.

At least one table of adjustable height should be provided in each area to allow disabled students to carry out a variety of activities. The table should be easily and discretely adjusted and not rely on separate mechanisms which may become lost. The table top may need to be shaped to support some students during practical experiments. For some serviced systems it is necessary to offer distinctly different tables for disabled students, whilst others are more able to incorporate an adjustable table into the overall scheme

For any further adjustments that might be needed, contact SSERC for advice.

2 Services

Each laboratory will be used to teach general science as well as a specialist science subjects (biology, chemistry and physics). All laboratories thus require water, gas,

Care should be given to the siting of these services to ensure that all activities can be carried out easily and safely. For instance, some gas taps at least should be near sinks to allow for distillation/reflux procedures in chemistry laboratories.

Water & drainage

All laboratories must have access to both hot and cold water. The minimum number of sinks for each laboratory should be five plus one deeper sink, with draining board, for washing up. Only the washing up sink should be supplied with hot water.

Student sinks should be fitted with bottle traps not dilution traps and have easily accessible valves to adjust the flow of water. Washing up sinks and those located in prep/storage areas should be fitted with dilution traps.

Corrosion resistant polypropylene (or similar) waste pipes should be fitted.

Backflow prevention

In Scotland, after the formation of Scottish Water, a revised set of byelaws came into force in August 2004, known as the Scottish Water Byelaws 2004 to ensure that there is no contamination of the public water supplies. If schools wish to alter or extend the water supply to their premises, they should consult their local water company (Scottish Water).

Water is now rated as one of 5 categories, ranging from 1, drinking water, to 5, the most heavily contaminated effluent. There has been considerable discussion about the requirements of taps and their fittings in school laboratories in order to prevent contamination of the water supply.

Waste from laboratories is generally rated Category 5 BUT, in a judgement from October 2000, it was decided that *"... arising from Health and Safety restrictions which should be in place, the laboratories of secondary schools can be considered less than a Category 5 risk*." [7] So school labs are rated as Category 4.

The main issue with water supply into laboratories is that there must be some means of ensuring that, under all circumstances, there is no possibility of waste water contaminating the incoming water supply. This is achieved by having an air gap between the bottom of the tap and the highest level of water in the sink (the overflow level). This should be at least 300 mm.

Problems arise because lab taps can, and often do, have lengths of rubber tubing attached which can drape in a sink, during distillation for example. These tubes can obviously compromise the air gap between water in the

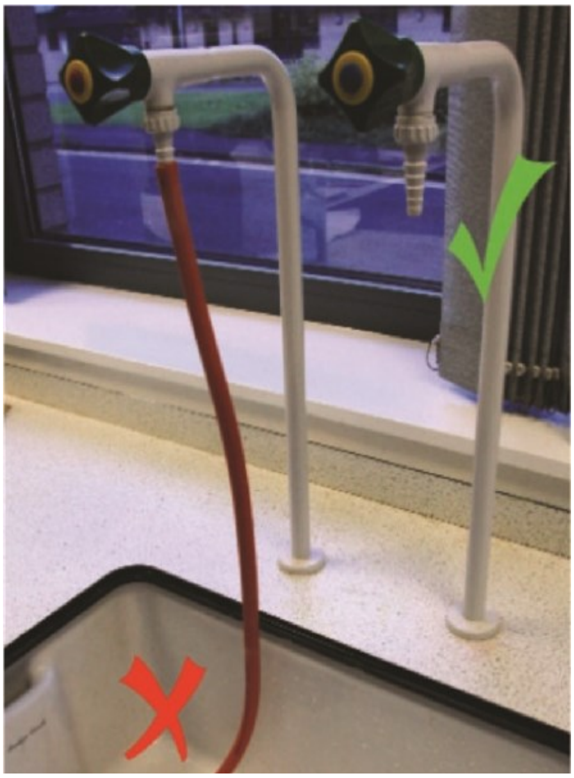
sink and the tap. A length of pipe attached to a tap means that it is possible for water in the sink or drain to flow backwards into the tap.

The way to prevent this is by having a large enough permanent air gap between any waste water and the incoming supply.

There is a number of air-gap devices on the market that can be fitted into the pipe system or onto the tap itself but none of these seems particularly sensible, in the context of school science.

The solution preferred by the water suppliers and recommended by SSERC is to provide the required air gap at the point where the water enters the lab or the science suite. This is achieved through some form of header tank that has a ball valve to control the inflow of water and an outflow pipe to the laboratory taps.

Science suites or laboratories which already have water supplied through a header tank need take no further action. However, since it is current practice to supply mains water directly to taps or appliances in any building, header tanks are no longer routinely installed.



For new labs it is possible to purchase a small compact header tank which will fi t under a bench (see Diagram). A small electric pump is fitted to the outflow pipe that responds, like those in power showers, by switching on only when there is a demand for water from one or more taps. The pump ensures that adequate water pressure is maintained to supply condensers, stills and water vacuum pumps, and means that the tank can be sited under a convenient part of the bench.

If there is no header tank fitted to a new or refurbished lab, Scottish Water will insist on interrupters being fitted to the taps and this will mean it is not possible to get adequate water pressure for most uses.

The diagram also makes clear that any plumbed -in eye wash station should be connected directly to the mains supply.

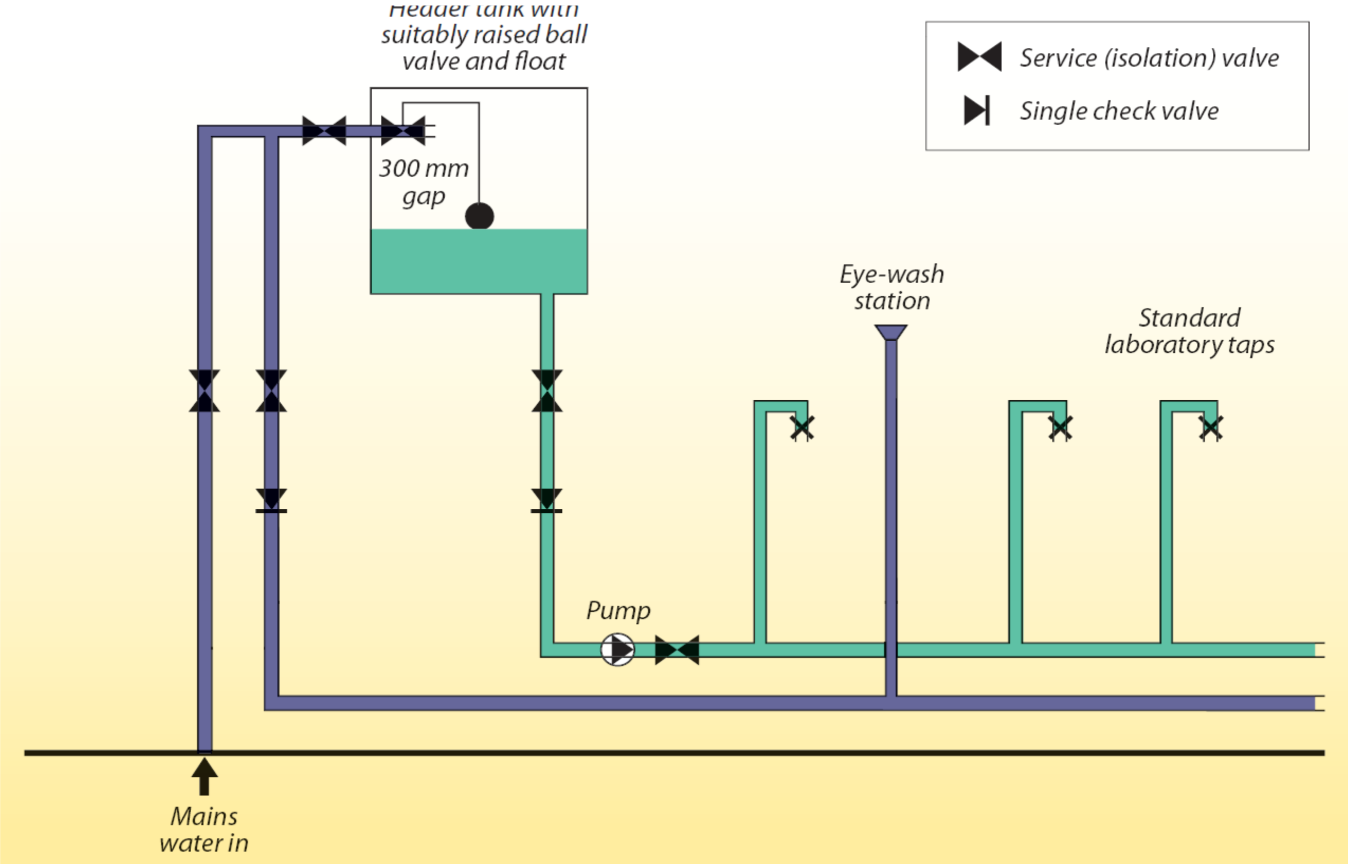
Whatever arrangements are made for the supply of water there should be a control valve (or tap) in each room to turn the water off in an emergency.

Water pressure

If the water coming out of the laboratory taps is at a high pressure, it will gush out far too quickly. When this happens, it splashes out of the sink (or any apparatus in the sink) and onto the surrounding bench area; possibly even into the eyes and/or on to the clothes of the people close by. This could be dangerous if the apparatus already contains a hazardous chemical.

In such situations there should be a valve in the supply that can be used to adjust the flow rate.

In any case, for maintenance purposes it is an advantage and possibly, depending on the design, a requirement for the supply to each tap or group of taps to be isolated using a service valve.



Sinks

Sinks in school labs have traditionally been made from fireclay. This is because it is resistant to both chemicals and heat and is easy to maintain. Fireclay is a very hard material which is very unforgiving if glassware is dropped into a sink made from it. Some alternatives include:

- Stainless steel - This must be acid resistant grade for laboratory use. Domestic stainless steel sinks are likely to have a very short life if installed in a laboratory.
- Polypropylene - Good chemical resistance but fairly easily damaged by heat.
- Cast epoxy - Good resistance to chemicals and heat.

Consideration should be given to installing plumbed-in emergency eye wash stations in laboratories and preparation areas.

Eyewash

While it is not essential, consideration should be given to installing plumbed-in emergency eye wash stations in laboratories and preparation areas.

If this is done, the eye-wash station should be connected directly to the mains water, not the header tank.

Gas

A mains gas supply should be installed whenever possible. If mains gas is not available, liquid petroleum gas (LPG) provides a viable alternative. However, this can only be used with equipment (Bunsen burners etc.) specifically designed for LPG. Standard mains gas equipment is not suitable and must not be used.

Isolating valves

An isolating valve should be fitted where a gas pipe enters each laboratory or prep room. Consideration should be given to ease of access to this and possible misuse. “Where this valve is not easily accessible an automatic shut-off system can be used which will also shut down the supply in the event of a leak. This can be restored manually by a switch which should be located near the teacher’s position or near the door.” BB80 [2].

There are various options available.

Manual valve	Cheap and appropriate in most situations. Preferably lockable in the
Solenoid valve	More expensive but has the advantage that the on/off switch/switches can be located away from the valve itself in a more convenient/ secure location. In the event of an electrical power cut these valves will not work and gas supply will also be lost.
Automatic system	These are much more expensive as they employ the use of sensors. A timer is used to switch the gas supply off out of normal school hours and pressure sensors are used to detect if any gas taps have been left open. These systems can be useful if vandalism is a real problem. However, they are less flexible than the other systems - resetting the timer to allow use of the gas supply outside ‘normal hours’ is not necessarily a simple task.

Gas taps

We recommend that as a minimum, one gas tap should be provided per student. To allow full and flexible use of the laboratory, as well as the above, additional gas taps should be installed in the teacher/demonstration area and at regular intervals on any peripheral benching.

Gas taps should be:

- Drop-down or spring loaded type so that they cannot be accidentally turned on.
- Located on the tops of benches never on the sides where they can be easily damaged.
- Positioned so that only short lengths of Bunsen burner tubing are required.
- Fixed firmly to the bench in a way that ensures any fitting screws cannot be accessed by students.
- Fitted with anti-rotation devices to prevent accidental or deliberate rotation by students.
- (in some cases at least) close enough to the water taps to allow for distillation using Bunsen burners

Switch	Location	Actuation	Purpose
Isolator	Distribution box.	Manual	To allow maintenance.
MCB or fuse	Distribution box.	Automatic	Prevents damage by overload, or short circuit.
RCD	Distribution box.	Automatic	Protects by detecting an earth leakage fault to remove danger.
Localised isolator with keyswitch	Classroom, near entrance.	Manual	Prevents socket outlets becoming live to remove danger.
Emergency cut-off	Classroom, prominent position.	Manual	Switches off a live socket to remove danger.
Functional switch	Socket outlet.	Manual	Operates load.
Functional switch	Apparatus or machine.	Manual	Operates load.

Electricity

As with gas, we recommend that, as a minimum, one socket should be provided per student. To allow full and flexible use of the laboratory, as well as the above, additional sockets should be installed in the teacher/demonstration area and at regular intervals on any peripheral benching.

Electrical isolation and cut-off

Electrical services to practical work areas including technical workshops and science labs should be fitted with localized switching for isolation and emergency cut-off.

There are two types of manual controls (isolation and emergency cut-off) that should be readily accessible in work areas for switching off the electricity supply. These are additional to other essential switches, some automatic, others manual, namely a manual isolator and fuse or MCB (miniature circuit breaker) in the distribution board, an RCD (residual current device), and functional switches at socket outlets and on apparatus.

The purpose of an isolator is to cut-off the electricity supply before certain activities take place. Generally this is to allow maintenance to be done safely. Additionally, in school practical areas, this should ensure that electrical apparatus or machines cannot become live when, for instance, students are not being supervised, or to ensure that the electricity supply is dead for certain dangerous practices such as learning to wire a plug. Quite differently, the purpose of an emergency cut-off is to switch off the electricity supply in a hurry once danger is present. This allows the supply to machinery or apparatus to be stopped when someone gets an electrical shock, or is at danger of being shocked.

The Architects and Buildings Division of the DfEE (now under the aegis of the DfE) in England have published a series of technical documents that are highly influential throughout the UK in the design of school buildings and the provision of facilities and services therein. They [8], with a supporting British Standard [9], both clearly recommend that emergency switching systems should be provided for school technology work areas. We recommend that these should also be provided for school science laboratories. A new British Standard [10] clearly recognises the need for switching in laboratories. This new standard not specifically tied to school laboratories, but "(its) recommendations may be used by all parties involved in the design, manufacture, installation and use of a new laboratory or in the refitting of an old laboratory".

The general point is that no one planning a laboratory installation can ever be entirely sure what activities might take place. They are general purpose rooms for practical activities. Because of the human element, there is scope for unforeseen activities with electrical systems. Added to the human element for surprise, there is much electrical apparatus in use, some of which may be very old and sub-standard, and therefore at risk of being faulty.

Means of isolation and protection should be provided in accordance with appropriate IEC standards. Emergency tripping facilities should be provided by means of a single stop push button to control all bench outlets from one position within the laboratory near the teacher's bench and main room exit. All bench outlets and certain fixed equipment should be protected.

There should be additional protection through MCB and RCD devices.

As a result of changes to the IEE Wiring Regulations [11] that came into force in 2008, all wiring to a.c. socket-outlets that are for use by ordinary persons and are intended for general use should be protected by RCDs.

There are exceptions. If disconnection from the mains supply could present a danger or difficulty then the socket-outlet supplying that equipment need and possibly should not be protected with an RCD. This might apply to fume cupboards, other types of local exhaust ventilation (LEV), refrigerators holding flammable or microbiological substances and freezers. Excepted socket outlets should be appropriately

marked (such as “Freezer only”). However, as the dangers from disconnection may not be great, it may not be reasonably practicable to except them.

This applies to all new builds and renovations but retrofitting is not mandatory.

Critical circuits specifically installed to remove hazards (e.g. fume extractor fans, lighting, alarm circuits) should not be controlled by the emergency system unless powered from socket outlets in which case the emergency cut-off should have overriding control.

ICT

If the network is wired, then network/internet access points should to be provided in each teaching space. This is to be in the ratio of one per two students with additional points being provided at demonstration areas, teacher’s workstation and around perimeter benching if applicable.

If it is a wireless network, an assessment should be made to ensure adequate connectivity and bandwidth for the maximum usage that may be encountered.

Suitable connections should also be provided for data projector and interactive whiteboard (if installed).

If an interactive whiteboard is being installed, care should be taken as to its siting, In particular that there is not excessive light shining on the board reducing the contrast of the display.

Facilities should be available for the mounting and connections for a television and DVD/video. (Unless this facility is incorporated into the computer/data projector setup)

WiFi networks

The internet is becoming more and more central to much of teaching and it is important that students have easy access to web-based resources when required.

While this is more a whole school than a departmental issue, there are specific actions that can be taken within a department. If the school has a wired (LAN) network, it should be possible to install a wireless router in a classroom, or centrally in a department to provide the wireless access that is so much more useful.

It will very often be desirable for students/ teachers to use mobile devices (phones/tablets) and access to WiFi should be facilitated for these as well as for laptops.

When installing a wireless network, it is important to make sure there is sufficient bandwidth for all those who might be using it. If in doubt, always opt for the highest bandwidth that is affordable - usage will only increase and if too low a rate is chosen, the system will soon become obsolete and need upgrading.

Specific requirements for specialist sciences

Physics

- Physics laboratories need the maximum number of electrical sockets, while sinks and gas taps may be less of a priority.
- There is a requirement for smooth long stretches of bench for activities on mechanics.
- All sinks should have covers.
- Full blackout is required for optical work.
- The steel frame of many laboratory tables can sometimes interfere with sensitive work with magnets. It may be preferable in laboratories intended for Higher or Advanced Higher physics to use wooden framed tables.

Chemistry

Chemistry laboratories require more investment. See Topics in Safety [5].

- Ideally all chemistry laboratories should have a ducted fume cupboard. If this is not possible then at least laboratory should be equipped with one.
- Five sinks in addition to the washing up sink are required.
- There should be double cold taps at each sink.
- Only the washing up sink should have hot water.
- Positioning of gas taps and electrical points in relation to the sink must be taken into account. so that practical work is not limited by accessibility of services.
- Each sink should have a bottle trap and valve adjuster for water flow beneath.

Biology

- Five sinks in addition to the washing up sink are required.
- There should be double cold taps at each sink.
- Only the washing up sink should have hot water.
- Positioning of gas taps and electrical points in relation to the sink must be taken into account. so that practical work is not limited by accessibility of services.
- Each sink should have a bottle trap and valve adjuster for water flow beneath.
- Benches for microbiological work should be non-absorbent. Any of the materials normally used in other laboratories should be suitable as long as they are well maintained. If not, disposable benchguard should be used.

3 Support areas

Guidance from the DfES, BB 80 [12], suggests that an area of between 0.4-0.5 m^2 per student place is required for storage and preparation areas in school science departments. The minimum area we would recommend is 0.5 m^2 per student place, with additional storage space of 0.6 m^2 in each laboratory. For a department with 10 teaching laboratories containing 20 student spaces in each and one 6th year lab (10 students) this equates to 111.6 m^2. This figure assumes that the laboratories are all located on the same floor and should be increased if this is not the case.

Preparation areas

If a single preparation area is to be common to all the sciences then there are several requirements that must be met. A ducted fume cupboard is essential as is a water-still or a de-ioniser. There must be areas suitable for carrying out microbiological activities, dispensing of chemicals etc. and also for testing and repair of electrical equipment. In addition, there must be adequate room to store several trolleys containing practical equipment.

Services should include gas, water and electricity. Two large sinks, preferably one being a Belfast type with double draining boards, should be provided for both cleaning and solution preparation. These should be fitted with dilution traps. A dishwasher, refrigerator and freezer, (separate units can provide more flexibility and will not require the replacement of both if one unit fails as can happen with a combined unit.) as well as a drying cabinet should also be provided. Bench material should be the same as that in the laboratories.

The preparation area must be well ventilated (at least 5-6 air changes an hour) to the outside either by mechanical or natural means (e.g. extractor fans with air inlets fitted or windows). Care should taken when installing air inlets to ensure that they are located in positions that allow a good flow of air through the laboratory.

The position of fume cupboards in the preparation area is important as different ventilation systems affect each other.

Fume cupboards should not be installed near doors or in the corners of rooms where air turbulence will affect their performance. Fume cupboards and room extractor fans should be on separate electrical circuits.

Many schools are installing recirculatory (filter) fume cupboards. These are fine in a classroom but are not really suitable for a prep room. The larger quantities of more concentrated chemicals will mean that the filter will need replacing more often than in a classroom and this will be expensive. In addition, in the event of a cracked bottle, broken lid or any other event that is releasing significant quantities of fumes, placing it in the fume cupboard to clear (a normal operation) will not be possible. In such an event hazardous fumes could be released into the prep room and possibly beyond.

Health & safety legislation uses the phrase 'so far as is reasonably practicable'. In a situation like this, the installation of a ducted fume cupboard is more expensive but the extra cost is quite justified and is more than 'reasonably practicable'.

In addition, running costs need to be considered. Replacement of filters, (annually in a prep room), more complex testing and disposal of used filters all add up to mean that recirculatory fume cupboards are considerably more expensive to run.

Lighting must be excellent (at least 300 lux). The use of natural light is helpful but direct sunlight, as in a classroom, can dazzle, make rooms very hot and render Bunsen flames nearly invisible. In the laboratories section of this guide we suggest the use of solar film and blinds to help reduce these effects.

The preparation room should have sited near the exit one each of a:

- bucket of dry sand and scoop for dealing with fires involving reactive metals.
- fire extinguisher - carbon dioxide or dry powder type, and;
- fibre-glass fire blanket.

The last two items should be mounted at least 1 m above the ground and all should be clearly visible and unobstructed.

Within the preparation area separate lockers should be provided for the storage of outdoor clothing and laboratory coats. Desk space, with room for a computer and internet/intranet, telephone and TV aerial connection provided. There should be shelving to take required books/documents (e.g. Local Authority guidance, SSERC publications, references etc. and DVDs if necessary).

Internet access is important in a prep room as these days a lot important information is most easily (sometimes solely) available online

Storage

The exact location and arrangement of storage areas is largely dependent on the layout of the school and the sciences within it. Storage areas need to be easily accessed by technicians but secure and inaccessible to students and unauthorised staff.

Ideally stores, especially chemicals stores, should open directly off the prep room. If this is not possible, the store rooms should be as close as possible to the prep room, which in turn should be close to the laboratories. As well as being more convenient, this is a safer system as it minimises the movement of (sometimes hazardous) materials and equipment along often busy corridors.

It is not a good idea to have too much equipment stored in classrooms as, given the level of usage of most classrooms, it may be difficult to access equipment without disturbing teaching activities.

Equipment

The main storage area for equipment is best located centrally, preferably beside the preparation and cleaning areas. If separate from these areas then there is no requirement for windows but good lighting (i.e. min 300 lux) is needed. Storage units can be of the freestanding rack type, which is flexible and can be arranged to suit the room or a rolling unit system, which can provide more space (see DfE BB 80 for examples of storage systems). Cupboards and drawers are also useful for certain items some of which should be lockable for security reasons, e.g. scalpels, portable balances. Cupboards and drawer units should be mobile for cleaning purposes.

Chemical

There are a number of pieces of legislation that require chemicals to be stored and handled safely - e.g. Health and Safety at Work etc. Act 1974, Management of Health and Safety at Work Regulations 1999, Control of Substance Hazardous to Health Regulations 2005 (COSHH), the Dangerous Substance and Explosive Atmospheres Regulations 2002 (DSEAR). Chemicals should be kept in a dedicated indoor store accessed from the main prep room. This arrangement increases security and reduces manual handling problems. Such internal stores should be large enough to allow the separation of incompatible substances. It is not necessary to have an additional outside store since these can be a security risk and often result in manual handling issues. This is only required if over 50 litres of flammable substances is being stores. There is no justification in a school for having this volume.

In SSERC's experience, for a chemical store holding a normal supply of flammables with a suitable ventilation rate, as described below, there is no danger of an explosive atmosphere developing and thus no need for spark-proof fittings to be installed.

In any event, the storage of flammable materials must be approved by the local Fire prevention officer and internal stores should have a Fire resistance of at least half an hour. In order to achieve this:

- All the walls should be of brick or block construction, not plasterboard studwork.
- The walls should reach all the way to the top of the roofspace above any suspended ceiling.
- All joints between walls and ceiling, floor or other walls should be sealed as should the holes for wires, pipes or ducting that pass through walls, ceiling or floors.

i) Ventilation:

Architects and building designers should be aware that the term ‘chemical store’ is often used in industry to describe a room that simply holds unopened containers of chemicals. The ventilation required for such a facility is significantly less than that for a school chemical store which will contain bottles of volatile chemicals that are no longer sealed and thus will leak fumes, albeit slowly

The store should be well ventilated to the outside either by mechanical or natural means (e.g. top and bottom venting through air bricks in external walls) and protected from frost. It is not necessary to have full air conditioning. Siting the store on an outside wall can be an advantage. Windows are not recommended as these present security problems and can expose chemicals to direct sunlight.

In the case of mechanical ventilation, the ducting should vent directly to the outside and should not link to any part of the wider ventilation or air-exchange system.

Unless the chemical store is used for dispensing chemicals then a ventilation rate of 2 room changes per hour should be sufficient. Unless a risk assessment under DSEAR suggests that an explosive atmosphere may develop, non-sparking fans are not needed.

The ventilation should be controlled by a separate switch, not linked to the lighting, outside the chemical store. If it is required to have a time switch, to come on for a certain period every hour for instance, there should also be a manual override.

ii) Temperature:

To many people's surprise there is no specific legislation that refers to temperature in a chemical store.

It is good practice to keep chemicals relatively cool. SSERC recommends around 15-20°C but temperatures in the low to mid 20s are acceptable.

The issue of temperature is, however, covered indirectly. As temperature increases, volatilisation of susceptible substances, particularly organics, increases. This leads to a greater concentration of these chemicals in the atmosphere, which is covered by COSHH and DSEAR (as mentioned above).

While a higher temperature will lead to shorter shelf lives for chemicals, provided the ventilation is sufficient to cope with the vapours, this is not a health and safety issue.

iii) Doors:

Doors should open outwards away from the store and have a vision panel fi ted. It must also open from the inside without the key for emergency purposes. We recommend that the door should be fitted with a Yale type lock, which is different from other locks in the department.

Only technicians and authorised teachers should have access to the store so there is no need for a locked 'poisons' cupboard. These can result in potentially dangerous situations where several highly incompatible chemicals end up packed closely together.

Iv) Floors: The flooring material should be impervious to chemicals. See Laboratories section of this design note. The floor should slope away from the door to a collection point so that any spillage is contained within the store. It should also, like in a laboratory, extend up the walls.

V) Shelving: Shelves should be shallow to avoid hidden bottles and preferably not be above "head" height. If need be, some items can be stored on higher shelves as long as it is nothing heavy or hazardous and that a suitable step-up are available for people to reach the items safely.

Materials used for shelving should be corrosion resistant. Metal brackets supporting wooden shelves are a common arrangement. In this case, the brackets should be checked periodically for signs of corrosion. There is no requirement to have a lip on shelves in the store.

vi) Flammable cabinet. A fire resistant, lockable cupboard which for safety reasons should be located as far away from the entrance to the store as possible should also be provided. If the chemical store has the requisite 30 minutes fire resistance then there is no absolute need for a flammable cabinet though it might be advisable for some of the more highly flammable substances. (It is also possible that insurance companies might insist on it).

Guidance on which chemicals should be stored in the flammable cabinet in case of limited space can be found on the SSERC website.

vii) Other cabinets

Chemical stores must be secure and have limited, controlled access. As such there should be no need for cabinets to hold corrosives, poisons or oxidising agents.

Corrosives are best stored at floor level in trays, or similar, that will prevent the spread of any spillage. (A common model is using ordinary storage trays with absorbent material in.) The steel cabinets normally sold for storing corrosives, as they are closed for most of the time, allow a build up of fumes inside and thus the cabinets corrode. Open shelf storage prevents this build up.

Poisons can be stored on the open shelves in the store. Only technicians and authorised teachers should have access to the store so there is no need for a locked 'poisons' cupboard. These can result in potentially dangerous situations where several highly incompatible chemicals end up packed closely together.

Oxidising agents need to be separated from potential combustibles. If organic/ inorganic chemicals are separated then the inorganic oxidisers can just be on the shelves with the other inorganics. If not, they, along with the organic oxidisers will need to be in a separate area, or in a cupboard

viii) Lighting: Lighting must be excellent (at least 300 lux) and the light switch should be located outside the store. Unless a risk assessment under DSEAR indicates that an explosive atmosphere may develop, non sparking light fittings are not needed.

ix) Emergency: The store should have sited near the exit one each of the following:

- bucket of dry sand and scoop;
- fire extinguisher - carbon dioxide or dry powder type, and
- fibre-glass fire blanket.
- There should also be a spillage kit located inside or close at hand outside in the prep room.

The last two items should be mounted at least 1 m above the ground and all should be clearly visible and unobstructed

Radioactive sources

When not in use, any radioactive material must be kept in a suitable store.

Suitable Store

Characteristics of a suitable store include:

- Physical security: provide a metal cabinet with keylock.
- Physical security: the cabinet should be securely attached to the fabric of the building, or to fitted furniture.
- Fire resistance: the metal cabinet should be of

steel so as to contain its contents in any Fire sufficiently fierce to gut the building. A standard steel storage cupboard designed for holding radioactive materials would suffice.

- Ventilation: provide a ventilation louvre on the cabinet.
- Dose restriction: The dose rate on an exterior wall of the cabinet should not exceed 2.5 μSv h^{-1}. Because radioactive materials held in storage within the store should be kept in receptacles, where possible, the only type of radiation that can be emitted from the cabinet walls is gamma. The cabinet must therefore be sufficiently deep to ensure that any gamma sources are stored at least 200 mm back from the door. The cabinet should therefore have a depth of about 300 mm, fitted internally with narrow shelves at the rear.
- Sign permanently fixed to the exterior of the cabinet door warning that the store may contain radioactive substances. The sign should conform to the Health and Safety (Safety Signs and Signals) Regulations 1996, 2nd edition 2009).

Area	Comment on suitable as site for radioactivity store
Store room	Suitable location provided it does not also store flammables or chemicals in moderate or large quantity. Store room should be adequately ventilated.
Preparation room	Suitable location if sufficiently large. Region within 1.5 m of radioactivity cabinet can be used only infrequently but can be used to store other apparatus. Technician workstations should be at least 3 m distant, or 2 m with one course of brick screening. A small flammables cabinet also sited in the preparation room is a risk that can be tolerated.
Chemical store	Unsuitable location in general, but if no other location is available, then the radioactivity cabinet can be sited in the chemical store provided that ventilation is adequate.
Flammables store	Unsuitable location.
Outdoor store	Unsuitable location because of security concern.
Laboratory classroom	Unsuitable location unless the room area is large (at least 80 m2). Renders a region of 3 m diameter unusable except for storage.
Sixth Year laboratory	suitable location, but renders a floor area of 3 m diameter unusable except for storage, or occasional occupation.
Corridor	Unsuitable location because of security concern.

Consideration should be given as to whether to place a safety sign on the door of the room containing the radioactivity store. The local fire officer may ask for this. In principle, the room should have a sign on the door, but in practice it may be impracticable because such a sign can encourage vandalism.

- **Suitable Store**

The store should not contain ancillary items other than handling tools and, possibly, shielding material.

Personnel type	Minimum distance without extra shielding	Minimum distance with shielding by one brick
Student	1.5 m	1 m
Teacher	2.5 m	2 m
Technician	3 m	2 m

Suitable store location: Risk to personnel from low-level radiation

The store can be sited where people work occasionally, but should not be sited near to where anyone works habitually.

The minimum safe distance to locate the radioactivity store is about 1.5 m from a student workstation, or 2.5 m from a teacher's desk, or 3 m from a technician's desk or workbench in continual use

If it is not practicable to obtain these minimum distances, then lower minima can be engineered by shielding the store. Dose rate can be halved with either 13 mm thick lead, or 100 mm thick concrete or brick. A simple temporary screen can be devised by placing a brick inside the storage cabinet between the gamma sources and person at risk. However if a school is being newly built or renovated, a permanent shield should be constructed. Using as a rule of thumb the fact that a standard brick attenuates gamma radiation by nearly 50%, we can summarise where the store should be sited relative to the workstations of personnel as follows:

The values in the second column above (minimum distances without extra shielding) should be interpreted as meaning direct horizontal distances in a straight line from store to workstation ignoring lightweight stud-partitioning walls. Any workstation in the room through the wall from the store should be sited outside the proximity zone. Please note that it is not unsafe for staff to work in the proximity zone. The risk only becomes significant if they remain continuously in the proximity zone for many weeks at a time, or if they stand alongside the cabinet for several hours.

The positioning of radioactive sources on one floor of a multi-storey building does not create a significant risk to persons on adjacent floors. Therefore the positioning of the store on one floor should not affect how personnel are sited on other floors

Suitable store location: Work-area factors

The store should be sited indoors in an area with suitable security. Comment on the suitability, or otherwise, of specific areas is given below.

Flammable liquids should not generally be stored in a domestic freezer or refrigerator. If it is essential to do so, then, if their flash-points are below the internal temperature of the apparatus, even small amounts should be placed in airtight containers. Otherwise they should not be stored there. If this is not sufficient, spark-proof apparatus should be purchased .

Greenhouses

A greenhouse is a valuable addition to a science department. There are no specific requirements for educational purposes and a standard greenhouse from a garden centre will suffice.

- Care should be given to its positioning. Ideally it will be built on, adjacent to the preparation room. If that is not possible, ease of access and security (particularly if vandalism is an issue) should be considered carefully.
- Glazing can be of glass polycarbonate or acrylic.
- The greenhouse will need to be ventilated. There are various automatic systems available though an automated system is not mandatory.

- The greenhouse may be heated, though this is not mandatory and consideration should be given to the running costs. Free standing heaters should never be used due to the danger of fire.
- There should be access to water in the greenhouse for watering.
- Any electrical sockets (or connections/ switches for lighting, heating

Science staff base

The requirements for a staff base will vary from school to school.

As it is a work space, it should be secure, well-ventilated (as a classroom) and be large enough for department members to prepare work, hold meetings or make refreshments, which should never happen in a prep room or laboratory.

Appliances in Science Departments

It is possible to purchase specialised refrigerators, freezers, dishwashers and the like specifically designed for use in laboratories. These are, however, hugely more expensive than domestic devices and in SSERC's opinion, there is no reason why much cheaper, domestic devices should not be used.

Domestic appliances in Science Departments

Dishwashers	While specialist laboratory glassware cleaners are undoubtedly more effective, they are greatly more expensive. As long as they are treated carefully, rinsing out containers beforehand (especially if they contain strong acids or other chemicals that can damage the stainless steel) there is no reason why a domestic dishwasher cannot be used for most glassware.
Refrigerators	A small fridge will be required, particularly in a biology area, for storage of some chemicals and reagents such as enzymes, foodstuffs for experiment, offal for dissection and microbial cultures.
Freezers	A freezer is necessary for making ice and longer storage of perishable items. Food for consumption must not be stored in this freezer.

4 Layout

The layout of a laboratory might seem to be of secondary importance but in fact it is fundamental. The layout will determine where the various service outlets are placed and once that is done, there is little room for change. So it is important to consider the issue carefully.

The layout of a school science laboratory is always going to be a compromise. There are three main types of activity that take place there and they have different ideal arrangements:

1) Teaching – Similarly to any other classroom, while the teacher is instructing pupils, it is important that they have as good a view of teacher and board as possible. This should be unobstructed and they should not have to turn round or sideways to get a good view.

2) Group work – Much work in science and other subjects is collaborative and required pupils to work in groups. This works best if pupils can be clustered in fairly small groups, facing each other for maximum interaction.

3) Practical work – most commonly carried out in pairs or small groups, (though frequently by individuals at 6th form level). The main determinant here is likely to be the accessibility of utilities such as gas and water. There are, however, other issues such as the ability of the teacher to see what is going on.

Separation of ‘wet’ and ‘dry’ areas.

If there is sufficient space, it can be useful to have a separate area of the laboratory dedicated to experimental work. This can make things easier with regard to space on bench tops etc. It does, however, need a larger space than the more common ‘dual use’ approach.

Moveable tables and adaptability.

Much is made of the importance of adaptability. For example, tables might be arranged in a U-shape for a class discussion, all separated for a test, arranged in blocks for group discussion and in long rows for practical work with dynamics trolleys running down ramps. In practice, teachers rarely make use of this flexibility on a day-to-day basis because it is too time consuming, noisy and disruptive to move tables. However, it is useful if the layout can be altered in response to the behaviour of pupils or changing fashions in teaching style or for special occasions such as open days.

The most important thing is to get the laboratory arranged in a manner that best suits the learning and teaching that will be happening there. The ability to rearrange furniture might be useful but is certainly not essential

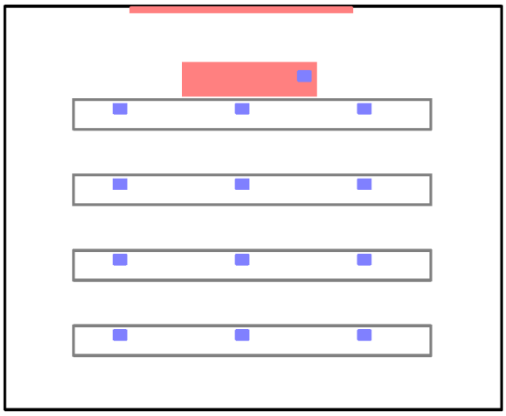
Here are a few common arrangements

Fixed benches with underfloor services

A traditional layout – though benches may be angled in some way to improve visibility.

Pros – All pupils facing teacher with reasonable visibility. Teacher has a good view of practical work.

Cons – Group work can be harder. In an emergency, it can take longer than desirable to reach pupils – gangways must be kept clear.



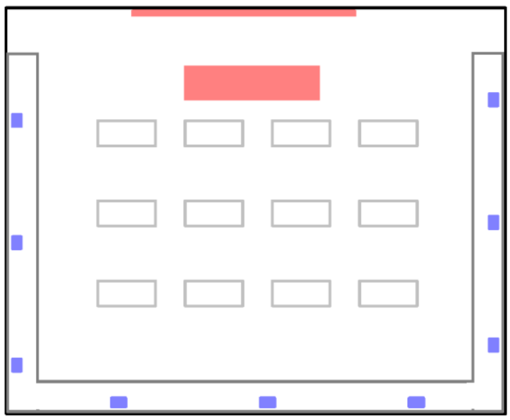
Fixed benches with services around the room

A common arrangement

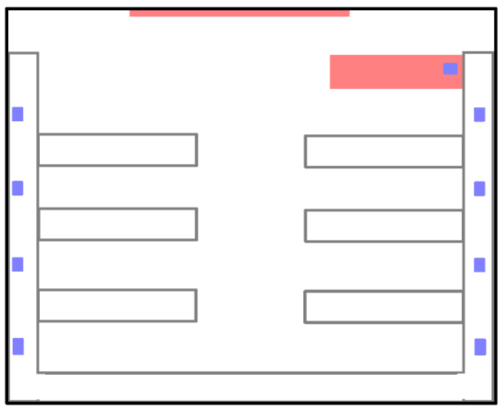
Pros – Maintains board visibility for much work. Tables can be moved for group work.

Cons – Pupils carrying out practical work often have their backs to the teacher. This is a Health and Safety issue.

If the peninsula benches are used (as in the lower diagram) space for practical work can be cramped.



Unless anchored to one side (as in the lower diagram) the teacher's bench will not have services for demonstrations.



Service pedestals with tables

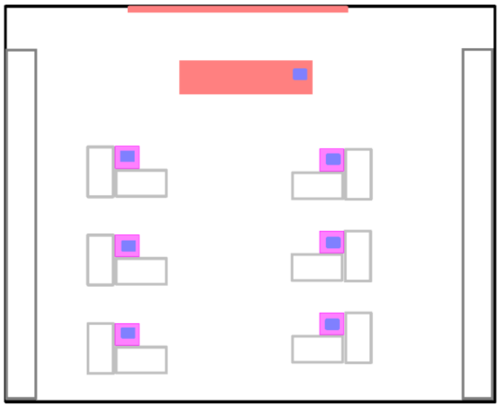
Another very common arrangement

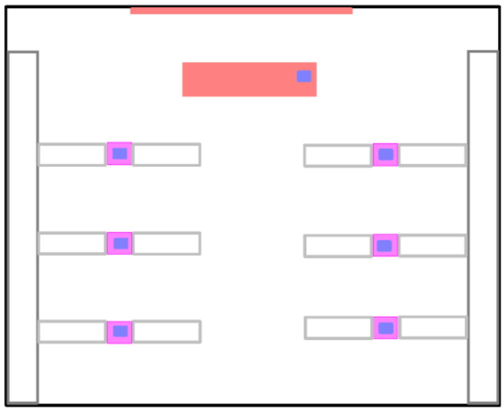
Pros – very flexible, particularly if the pedestals are separated by multiples of 600mm. Teacher has good vision for practical work.

Cons – pupils line of sight to the board can be impar-ired. May end up sitting sideways or sometimes even with their back to the teacher.

A variation is shown in the lower diagram. The outer benches of each peninsula can be fixed or moveable.

It is less flexible than some other island arrangements but sacrifices some of their flexibility.



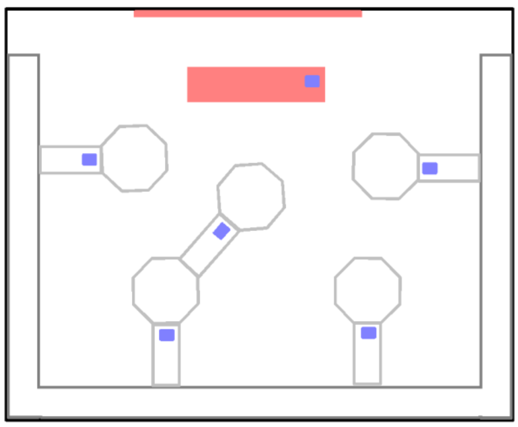


Octagons

A stylish new design

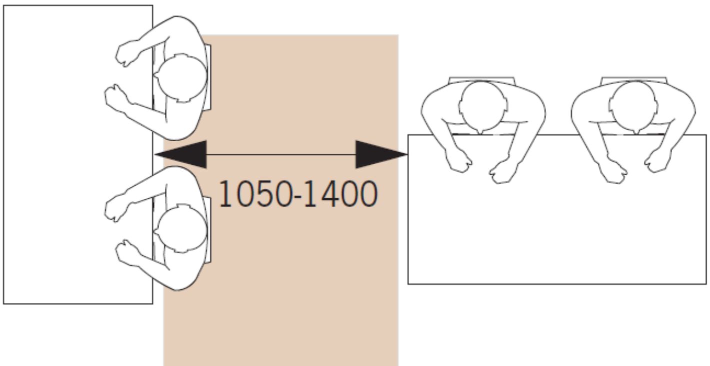
Pros – clean, modern look. Excellent for practical/ group work

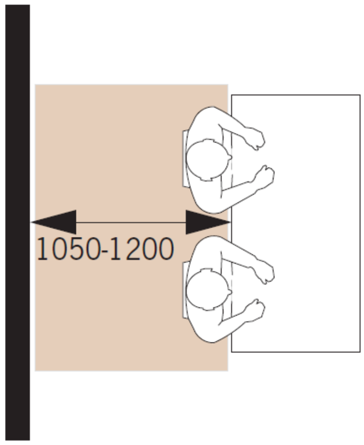
Cons – movement of the teacher can be impaired. Some pupils will have their backs to the teacher. Quite an inefficient use of space

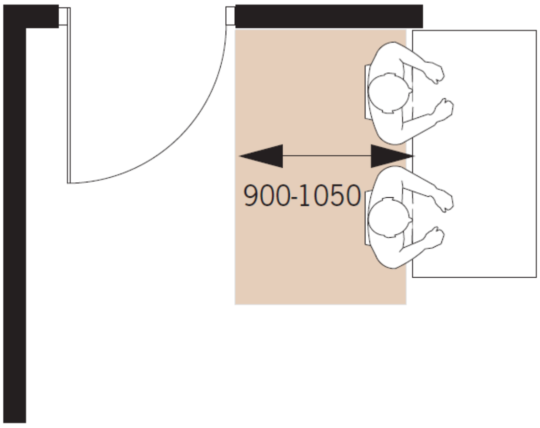


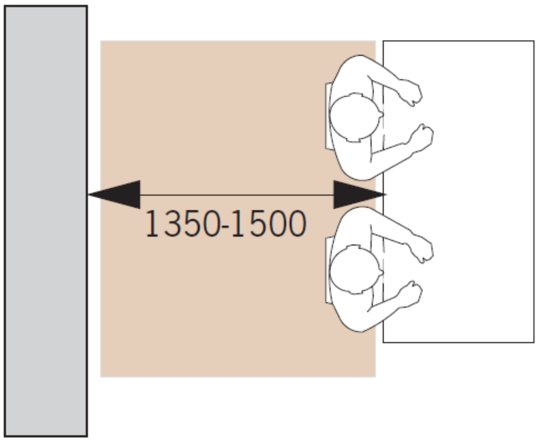
Spacing

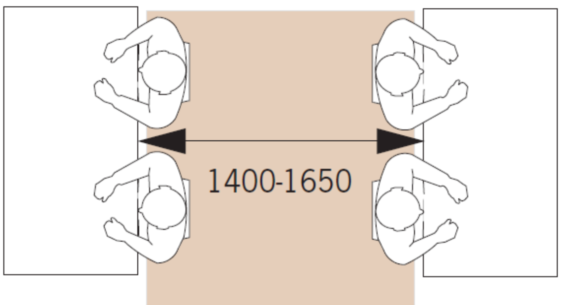
The layout of the laboratory will often be determines, at least in part, by the space available. There needs to be adequate space between desks, walls and other furniture to allow for circulation as well as comfort,

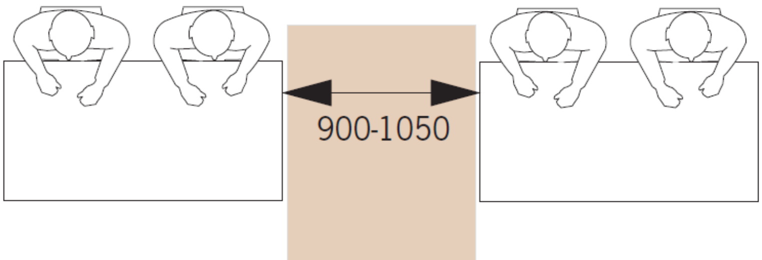












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[2] **Building Bulletin 80** (revised 2004) Science Accommodation in Secondary Schools, Schools, Building and Design Unit at the DfES, page 7.

[3] **Practical Fire Safety Guidance For Educational And Day Care For Children Premises**—Technical Annex 13.8.

[4] **Building Bulletin 80** (revised 2004), page 48.

[5] **Topics in Safety,** ASE H&S Committee, (3rd ed, page 32.

[6] **Building Bulletin 101,** July 2006, version 1.4, page 14.

[7] **Water Regulations Advisory Scheme (WRAS)-** Laboratories - risk of contamination by backflow.

[8] *"All fixed equipment should be permanently wired to the electrical distribution system and be controlled by an isolating switch located either on the equipment or within 2 m of, and accessible to, the operator. For certain machines the switch must be lockable. Most machines also require individual emergency stop buttons, controllable via knee or foot."* Section 6.2.

"Each work area containing fixed electrical equipment should have a lockable single switch disconnector and an emergency stop system. These should control all the electrical power circuits except those serving equipment which is designed to remove a hazard (such as a fume cupboard)...". Section 6.3.

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[9] **Requirements for electrical installations IEE Wiring Regulations,** 17 th edition, BS 7671:2008.

[10] *"Emergency switching systems should be provided in each separate work area. The systems should switch off all circuits supplied via the switch-disconnector in an emergency. Critical circuits specifically installed to remove hazards (e.g. fume extractor fans, lighting, alarm circuits) should not be controlled by the emergency system."* **BS 4163:2000,**

Health and safety for design and technology in schools and similar establishments - Code of practice: Section 5.2.5, Work area emergency switching systems. Revised to BS 4163:2007 (available from BSI online shop).

[11] *"Means of isolation and protection should be provided in accordance with appropriate IEC standards. Emergency tripping facilities should be provided by means of stop push buttons or on load switches to control all bench outlets from at least one position within the laboratory. All bench outlets and certain fixed equipment should be protected."*

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[V] Building Bulletin 88 Fume cupboards in schools. This *document no longer exists. However, the DfE passed it on to CLEAPSS who have revised it as their guidance document G9. It is available either on the CLEAPSS website or via SSERC.* https://www.sserc.org.uk/health-safety/chemistry-health-safety/chemistry-hs-background/laboratory/laboratory-design/

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[X] The Water Supply (Water Fittings) (Scotland) Byelaws 2014 , http://www.scottishwater.co.uk/assets/business/files/water%20byelaws%20documents/swbyelawsexplained.pdf

[XI] A Science Strategy for Scotland, Scottish Science Advisory Committee (2001), page 11, 20, http://www.gov.scot/Resource/Doc/158401/0042918.pdf

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