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The Earth is a balloon

I met an old friend at a conference recently and sitting beside him waiting for the afternoon session to begin I asked him what it had felt like to be upsidedown for several weeks. He had just come back from Australia. Taking a couple of moments for the allusion to sink in, I got given a withering look. The chairman was about to commence speaking so I quickly recast the question, "Surely you did notice that you were upsidedown?" "You must be joking!" was the reply.

I make a habit of asking these questions to anyone I meet who has recently travelled to the Antipodes. It doesn't really matter whether the person so questioned, as at that recent conference, is a scientist, or a youngster having a gap year. The response is the same. Nothing was noticed. The Earth is round? We all believe it is. But ask anyone how he knows that it is round and you are unlikely to get a convincing answer.

Last southern winter I emailed some scientists wintering in the Antarctic with the same question. Back came the answer, "Orion! It's upsidedown here relative to how you view it from the UK." Great though it was to get an intelligent answer it won't do, supporting as it does the flat Earth and round Earth theories equally nicely. If that surprises you, then imagine modelling the flat Earth with a large meeting hall. The Sistine Chapel will do, a place associated with the theory of geocentricity long after it was discounted in Britain. The Chapel floor models the flat Earth while the vaulted ceiling with its Michelangelo panels represents the heavens. The central panel has the famous scene of the creation of Adam. The outstretched arm of God almost makes finger contact with a similar outstretched arm of Adam.

Entering the Chapel as you do from one end, imagine gazing at this central panel with its two figures, X on the left, Y on the right. Now walk to the far end of the Chapel turn round and look back at the panel. The scene has been inverted. X is now on the right and Y is on the left. The Orion answer does not convince.

Whitehead warned against holding what he called "'inert ideas' – that is to say, ideas that are merely received into the mind without being utilized, or tested, or thrown into fresh combinations". The round Earth idea is one such. Others may be the heliocentric model for the Earth and planetary motion, that moonshine is reflected sunlight, the atomicity of matter, atomic elements, and gravity. Why gravity? Why not levity? Flames rise!

How many of us ask "how do we know …..? Why do we believe ….?" questions? How do we know the Earth is round? It is a reasonable question to set a class? Be patient waiting for the theory to be confirmed. It may take days or weeks for evidence to be collected, mostly second hand, for inferences to be made and for false inferences to be rejected. The moonshine question is a good one because evidence to substantiate the idea that moonshine is reflected sunlight can be directly collected, night after night, over a period of a month. The recent Inspectorate report on science teaching is generally critical of S1/S2 science and an over-reliance on worksheets. Call forth these 'inert ideas' that everyone believes, but few can justify, and test them, one by one.

Jim Jamieson

Back of envelope stuff

1. Typical science equipment budget as percentage of SSERC recommendation:

Physics equipment budget	=	£1.9k
3 sciences equipment budget	=	£5.7k
SSERC equipment recommendation for mean department of 3.2 labs:		
Biology	=	£9.7k
Chemistry	=	£9.7k
Physics	=	£12.9k
Total	=	£32.3k

Implies mean science equipment budget is 18% of SSERC recommendation

2. SSERC recommended science budget as a percentage of staffing costs:

Mean no. of labs per dept.	=	3.2
Mean no. of science teachers	=	9.6
Mean no. of technicians	=	2
3 PTs at £31.8k each	=	£95k
6.6 teachers at £25.6k each	=	£169k
2 technicians at £16k each	=	£32k
Total	=	£296k
+ 15% for employer's NI and superannuation	=	£340k

Implies SSERC recommended equipment budget for teaching science is 10% of staffing costs.

3. SSERC recommended equipment budget as a percentage of national expenditure on science:

National science expenditure	=	£800m
Recommended equipment budget to teach science per typical school	=	£32.3k
No. of council schools	=	357
Total recommended budget	=	£11.5m
Percentage of national expenditure	=	1.4%

4. Current proportion of national science expenditure going to school science equipment:

18% of 1.4%	=	0.26%

5. Current proportion of national science expediture going to school technology education:

Annual mean Physics budget	=	£3.8k
Mean Physics/Technical weighting	=	2.0/2.3
Estimated mean technical subjects budget	=	£4.4k
Number of council schools	=	357
Actual total expenditure on technical subjects	=	£1.6m
Percentage of national science budget spent on technical subjects	=	0.2%

Data for our back of envelope calculations were taken from SSERC's Biology, Chemistry and Physics equipment lists (downloadable from www.sserc.org.uk), the funding suvey conducted by Stuart Farmer (pages 4-8 of this issue) and the Scottish Science Strategy Review (August 2001).

Multimedia report

From anecdotal reports of schools with unboxed computers, or unused Blue Box sensors, it is clear that giving schools ICT equipment is not nearly enough. Much additional training and on-going support is needed. It is timely to see that this matter has been reported on knowledgeably by Jerry Wellington. The upbeat message is that the use of multimedia has clear benefits for teaching and learning, but the downside is that it is far from easy to successfully build it into school life.

The research looked at the use of *Chemistry School*, a multimedia package by New Media Press. Factors examined included how, when and where teachers used multimedia, the benefits and drawbacks, and whether its benefits outweighed the time and energy needed to implement it.

Feedback from trial schools on the web site showed that:

- A web site can provide the resources which teachers need to make effective use of multi-media software.
- Active day-to-day technical support for teachers is essential when they start using multi-media resources - training on its own is not sufficient.
- The combination of a telephone help-line and a web-site can provide effective support and solve technical problems at a distance.
- Help and encouragement from IT co-ordinators and senior management is critical.
- Access to just one stand-alone computer linked to a projector costs about the same as the purchase of three computers and can be much more effective.
- The use of a network is even more effective, but the fact that networked computers are often outside the science department, under the control of someone else, acts as a deterrent.

Drawbacks included too much play and not enough learning, information overload, irrelevant data, replacement of simulations for practicals, and lack of time.

Factors for success appear to be:

- a supportive school
- a helpful ICT coordinator
- time and support of an ICT technician
- the availability of ICT resources
- staff and pupil confidence
- software that clearly offers added value in teaching and learning
- a key person in the subject area

The full report of the evaluation of this project is available free from Nuffield Curriculum Projects, or can be downloaded from www.scienceschool.com.

Grovels, various

Web-whacked

Firstly we owe an apology to those of you who tried, in late September and early October, to access either the SSERC web site (www.sserc.org.uk) or the two other sites which we currently host. These are the Science Online Support Network site at : www.solsn.org.uk and SETNet Scotland at : www.setnet-scotland.org.uk.

We had deliberately closed all of these sites because of recurring problems due to faults outwith our own local area networks and which were not under our control. Things are now more or less back on an even keel. Access to all of the sites has been restored. We are sorry for any inconvenience this loss of service may have caused. However, we judged it to be in the best interests of all of our clients that we secured our sites against damage at a time when the internet in general was being plagued by viruses such as the *Code Red* worm virus, *Nimda* and variants thereof.

Meantime, those of you regularly use the Web should be aware that there are a lot of infected sites and Email address books out there. There are still many users who don't take even the simplest of steps to guard against virus infections or keep their operating system security up to date.

Double vision?

NNo, you wweren't seeing things. We did print the same graph twice in the ICT survey article in the last issue (Fig.2 repeated as Fig.3) . We are very sorry, and will try not to do it again. Guess who first spotted the error? None other than the amazing Dr Flood - chemist, scholar and, depending on your particular shade of green, gentleman - of whom more, anon.

LED safety

A new report has concluded that ultrabright LEDs do not pose a retinal hazard

The inclusion of light emitting diodes (LEDs) within the most recent laser safety standard to be issued by BSI in 1994 [1] has been bothersome to say the least. "Never stare into the beam", is the cardinal rule of laser safety. Yet it is something that we do with LEDs. We do stare at them! They are patently harmless!

But are they all harmless, even the so-called ultrabright, superluminescent ones? Perhaps not, at least according to the 1994 British Standard. Some of the brightest LED products exceed the emission levels for the intentional viewing of laser radiation. For this reason the SEED Circular [2] on the use of lasers in schools warned

> As an interim measure before LED classification comes into operation … high power LEDs described as ultrabright or superluminescent or equivalent should be used with great caution and in accordance with the Code of Practice (for Class 2 lasers).

Because of the confusion relating to the actual risks of high intensity LEDs, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) organised a panel of experts to review the potential hazards. The outcome is that all surface-emitting LEDs, whether visible or infrared, are safe [3]. "Only because of the extraordinary worst-case assumptions built into laser safety standards could one reach a conclusion that an LED or infrared LED poses a retinal hazard", comments the report. It recommends that safety evaluations for LEDs follow guidelines for incoherent sources rather than laser safety standards. On the other hand, diode lasers should be treated as lasers.

One of the flaws of applying laser safety standards to LEDs is that an LED source has a finite size. The light emitting part is typically about 1 mm overall. Thus when an LED is viewed directly, the retinal image is quite large, ensuring that the retinal irradiance (measured in W/m^2) is well below safety limits. By contrast, lasers are treated as having point sources, which can result in a much greater concentration of light on the retina.

In consideration of the ICNIRP statement, the objection [4] raised by SSERC to the use of ultrabright LEDs in educational equipment is withdrawn. Equipment we know of with this technology includes the Speed of Light Kit C55669 (formerly 432.010) from Unilab, and the LED Colour Maker SS-14160 from Nicholl Education.

References

1. BS EN 60825-1 : 1994 *Safety of laser products* Part 1. *Equipment classification, requirements and user's guide* BSI
2. *Circular No. 7/95* Guidance on the use of lasers in laboratory work in schools and colleges of education, and in non-advanced work in further education establishments *SEED 1995*
3. *ICNIRP statement on light-emitting diodes (LEDs) and laser diodes: Implication for hazard assessment* International Commission on Non-Ionizing Radiation Protection 2000 www.icnirp.de/download.htm
4. *Ultrabright LEDs in educational products* Bulletin 188 SSERC 1996

Biology

Agar Agony Aunt

pH problems

We've received enquiries on the need to adjust the pH values of some media. Generally, it is advisable to get the pH value of, say, a malt extract agar or other medium designed to favour fungal growths, down to pH 5.5 or thereabouts. This tends to favour the growth of moulds and yeasts generally but is particularly useful, obviously, when they are acidophilic.

We have also been asked just how accurate this pH adjustment needs to be. For example, one school wished to make up a DIY recipe using malt extract bought locally but said they didn't have a suitable pH meter to check the pH adjustment. In fact a pH meter isn't really necessary. We got satisfactory results with a crude w:v mix of 2% malt extract and 2% agar powder. We used a suitable narrow range pH test paper to adjust the value to ca. pH 5.5, with a few drops of bench sulphuric acid, prior to autoclaving.

We tried the effects of not so adjusting the pH. The results were interesting and showed a range of tolerances. This would make a good mini-investigation.

The red yeast *Phaffia rhodozyma* and *Saccharomyces cerevisiae* grew much less well in an unadjusted medium whilst *Mucor hiemalis* and *Penicillium roquefortii* were more tolerant of a somewhat higher pH, growing quite well in the unadjusted media.

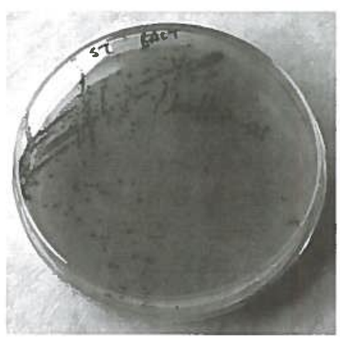

Figure 1

Phaffia rhodozyma on malt agar - no pH adjustment

Figure 2

Phaffia rhodozyma on malt agar adjusted to ca. pH 5.5. Inoculated under same conditions and same initial time as for Figure 1.

Funding survey

A typical physics department gets about seven times less than it needs to spend on equipment finds Stuart Farmer, PT Physics, Robert Gordon's College, in his survey into the resourcing of Physics departments in Scottish secondary schools.

Whereas the provision of specialist physics teachers is relatively good at present, anecdotal evidence points to a shortage of modern apparatus. In his opening address to the Association for Science Education (ASE) Scotland Annual Conference in March 2001, Jack McConnell, MSP, the Minister for Education and Europe, noted that the school science departments he had visited did not usually have the modern resources and resulting attractive atmosphere found in some other areas in schools.

Two key weaknesses identified in the recent HMI report on science teaching [1] were:

- *"equipment which had reached the end of its useful life or was not suited for modern scientific purposes;*
- *lack of suitable access to, or appropriate software for, modern ICT equipment."*

Guidelines regarding how much resource is required to fund science curricula are available. In 1997, the Royal Society conducted a detailed costing of the equipment and materials required for teaching the science National Curriculum for 11-16 year olds in England [2]. SSERC subsequently built on this work to cost the equipment required for the Scottish physics curriculum for 12-18 year olds [3]. This work provides a useful benchmark against which to measure the actual allocations in Scottish schools.

During 1992/93 a survey of 165 science departments in England and Wales was conducted by the National Science Advisers and Inspectors Group [4]. As part of the survey, schools were asked to calculate the mean amount of money available to spend on science resources. The results are shown in Table 1.

Type of school	Mean of means	Range of means
11-16 schools	4.3p / pupil-hour	3.2-6.3p / pupil-hour
11-18 schools	5.4p / pupil-hour	3.2-9.3p / pupil-hour

Table 1 *Science spending per pupil-hour (from Borrows, 1994).*

Putting this into context Borrows writes

"Thus for a Year 7 pupil in an average 11-16 school ... the sum available is £3.78. When a popular Year 7 textbook costs £7.25 it is easy to see why many schools cannot afford to give pupils textbooks. ... in a typical seventy minute science lesson, the school has just £1.26 to spend on that lesson. Break one thermometer (price £1.72) and that is the allocation for half the next lesson as well. Even copying a worksheet for each pupil (at 4p per sheet) costs £1.02, and does not leave much for copper sulphate and batteries - let alone top pan balances [at perhaps £800 each]."

The survey

The aims of the study were to:

1. ascertain the level of resource allocation to Physics Departments in Scottish Secondary Schools for spending on physics teaching materials.
2. compare this allocation with costing studies on the level of resource required to fully deliver the physics curriculum.
3. determine how resource allocation decisions are made within schools.

A postal questionnaire was sent to the PT Physics in all of the 392 secondary schools or schools with secondary departments in Scotland. 357 these are education authority comprehensive schools and 35 are independent schools. The survey related to session 2000-2001. It set out to investigate the levels of funding on teaching materials (i.e. apparatus, books, photocopying, ICT equipment etc.) in comparison with SSERC recommendations; and how resource allocation decisions are made within schools.

A response rate of just over 30% was obtained, consisting of 110 local authority and 10 independent schools. Responses were received from schools in 29 of the 32 local authorities and from urban and rural schools with rolls between 196 and 1860 thus representing a broad cross-section of Scottish schools.

Method of calculating the total physics budget allocations

The physics allocation was added to one third of the science allocation to identify the total physics budget for each school. It was assumed that one third of the science could be classified as physics, the other two thirds being biology and chemistry. This also allowed for joint bids that had been made by all three science departments for shared equipment, particularly ICT equipment. As the SSERC recommendations are given per physics lab it was assumed that if all of the physics taught were concentrated in certain laboratories then one third of all science laboratories within a school could be classified as physics laboratories. This generally gave a slightly higher figure than PTs had identified as physics laboratories - i.e. laboratories where certificate physics courses were taught, but the two figures were generally consistent with each other.

Comparison of physics allocations with SSERC recommendations

As can be seen in Figure 1, apart from one notable exception, the total budget allocations for physics are considerably below that recommended by SSERC for

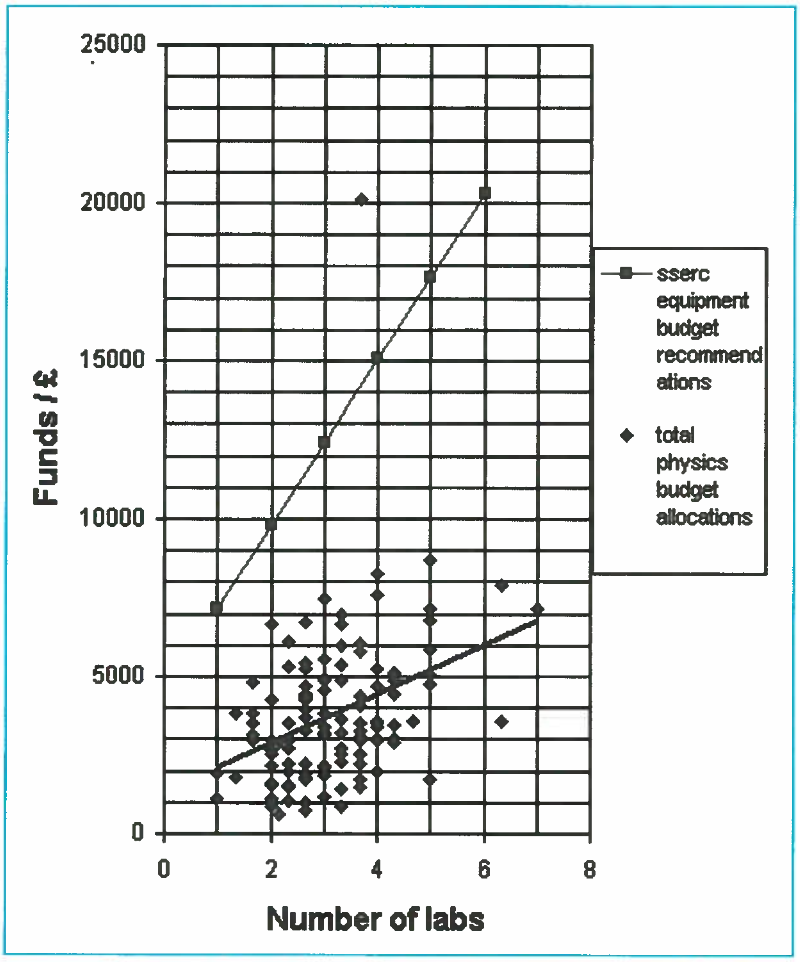

Figure 1 Comparison of total budget allocations and SSERC recommendations.

stationery items as well as equipment. PTs were asked to give a breakdown of their spending on equipment, non-physics-specific ICT equipment, textbooks, photocopying and stationery. A breakdown of the spending between equipment and other materials is given in Table 2. This is a slight underestimate of the amount spent on photocopying. Several schools had access to central budgets for the copying of items such as assessment materials for which they were not able to give a budget sum.

During 2000-2001 four PTs had spent all of their budgets on photocopying and stationery rather than on equipment. Those which spent the highest percentages on equipment had been successful in obtaining a large development bid, usually for ICT equipment.

Three local authority schools expected pupils to purchase some of their own books. This was for books of examination past papers or revision guides only. Even in the independent schools responding, the majority did not expect pupils to provide all of their own textbooks. Many departments were unable to supply textbooks to pupils with the effect of further increasing photocopying costs.

equipment only. The one school (a local authority school) that had received more than the SSERC recommendation had been successful in obtaining a bid of £18 000 for ICT equipment in the form of seven laptop PCs with PASCO interfaces and accessories.

The mean number of physics laboratories in the schools providing data was 3.2. This corresponds to a SSERC recommended equipment budget of £12 950 per annum (see Appendix 1). Results reveal a mean total physics allocation of £3 798 per annum. This corresponds to 29.3% of the SSERC equipment recommendation.

This mean budget of £3 798 has to provide for all teaching materials such as textbooks, photocopying, jotters and

Spending category	Mean percentage	Range of percentages
Equipment - physics and ICT	51.0	0.0 - 87.4
Photocopying, textbooks and stationery	49.0	12.6 - 100.0

Table 2 Physics spending breakdown.

Taking this into account the typical school spends around 51% of £3 798 (i.e. £1 936) per year on equipment, a considerable proportion of this being ICT-related. This represents 14.9% of what SSERC recommend as being necessary to allow for maintaining and replacing the equipment to deliver the physics curriculum.

Royal Society recommendation comparison

PTs were asked to provide information on numbers of pupils studying the various physics and science courses and their time allocations. From this the number of physics teaching hours was calculated for each school and hence the funds available per pupil-hour worked out. Table 3 shows a comparison with the Royal Society recommendations (see Appendix).

	Mean funds per pupil-hour	Range of funds per pupil-hour
Sample schools	11.7p	2.2 - 27.9p
Royal Society recommendation	15.8p	

Table 3 Physics funds per pupil-hour.

Funding

The Royal Society recommendation:

- does not allow for the typically 49% of funds that are not spent on equipment;
- is for 6 laboratories rather than a mean of 3.2 giving some economies of scale;
- is based on a typical English class size of 25 pupils rather than the Scottish maximum of 20;
- is for all sciences and does not allow for more expensive post-16 work.

All of the independent schools in the sample, except one, had above the national average spending per pupil-hour (the exception was 0.2p per pupil-hour below the national average). Most of the independent schools were near the top end of the range of spending values.

Comparison of current budgets with past budgets

Despite schools currently receiving these modest amounts, over a third of the PTs indicated that this was a greater than normal allocation. Reasons given were special funds from central government and successful bids for the introduction of new courses, in particular Advanced Higher Physics.

Allocation was:	Percentage
more than normal	35%
similar to normal	43%
less than normal	14%
unsure	7%

Table 4 *Comparison of allocation with previous years.*

PTs provided many comments of which the following few give a representative flavour:

"Over the past 10-15 years we have become used to underfunding and have got by with what we have. We have made no purchases of large capital items and this is restricting the educational experience of pupils."

"We have made do for so long that we have entered a mindset/ culture of expecting the equipment we put in front of pupils to be 30 years old and garbage."

"The whole school budget was only £38 000 this year - industry would call this petty cash." (PT in school with roll of 950)

"I have been PT Physics for 30 years and have not witnessed such a low allocation!"

"I feel strongly, having been PT for 20 years that the allocation does not cover a modern physics department and has not kept pace with inflation. In 1983-84 I got £1 340, this year £1 294."

"Our regular basic capitation has remained the same over the last 20 years."

The increased use of ICT in schools has also impacted on physics equipment budgets. This was remarked on by several PTs with comments such as:

"We have less cash than in 1990 with more than double the numbers of physics pupils - all the money seems to go to ICT."

"Very difficult to get money for expensive apparatus except for computers which comes from other funds and can't be vired into subject specific apparatus/equipment."

"Constant upgrading in 'Technological' subjects has been to our detriment."

These statements indicate that many departments have not received a proper equipment allocation for 20 years or more.

Resource allocation decision making

PTs were asked how resource allocation decisions were made in their schools. The questionnaire included some examples to give an indication of the type of information being asked for. Respondents tended to answer in relation to these examples. A breakdown of responses is given in Table 5.

Several PTs made comments such as *"Method unknown - some mysterious magical process!"* or *"Mystery to me!"*. Often when PTs did know the basic method, they were not able to give details. Very few of those who knew funds were split between per capita and bids could give which percentage of the total available funds were allocated by each method. Where a formula including a subject weighting was used to allocate per capita funds (57% of schools), only 25% gave any indication of the weightings used (see Table 6).

Method of allocating departmental funds	Percentage of schools using method
All funds allocated on per capita basis	30%
All funds allocated by bids	5%
Combination of basic per capita plus bids	43%
Historical/incremental allocation	4%
Unknown method	18%

Table 5 *Methods of allocating departmental funds.*

Subject area	Relative mean weighting
English	1.0
Mathematics	1.0
Modern Languages	1.0
Modern Studies	1.0
PE	1.0
RME	1.0
PSE	1.1
Geography	1.1
History	1.1
Music	1.4
Computing Studies	1.6
Science	1.9
Business Studies	1.9
Biology	2.0
Physics	2.0
Chemistry	2.0
Home Economics	2.2
Art	2.2
Technical subjects	2.3

Table 6 *Subject weightings.*

The mean weightings for the four schools that provided full information is shown in Table 6.

The partial data provided by other PTs was consistent with that in Table 6. Compared to Physics - Technical, Home Economics and Art were consistently on greater weightings, with Computing and Business Studies on similar weightings to Physics.

Although the majority of PTs said their school used some form of bidding system to allocate funds partially, comments suggested that there was an underlying 'historical budgeting' element at work in some schools where each department had to be seen to get 'their fair share' of the bids.

Despite the method of allocation often not being known, the final departmental allocations were made public within three-quarters of schools.

As can be seen from Table 7, in almost half of the schools headteachers were the sole budget allocation decision makers and in most others they played a central role. Several PTs made comments in relation to the operation of Finance Committees, such as "Finance Committee [makes decisions] in theory. In practice they 'rubber stamp' Headteacher's decisions".

Who decides on the budget	Percentage
Headteacher only	44%
Headteacher and member(s) of SMT	33%
Finance Committee	20%
Unsure	3%

Table 7 *Budget decision-making.*

Results also showed a poor relationship between budget allocations and development plans, with 28% of PTs indicating that budget allocations were closely related to development plans and 72% indicating that they were loosely or not at all related.

Evaluation of budget allocations against planned outcomes gave a similar result, with 5% of PTs indicating that this always occurred but 37% that it never occurred and 27% unsure whether it did or not.

Conclusions

1. The level of funding of Scottish physics departments is considerably less than is required to adequately deliver the intended curriculum. Most departmental funding allocations only cover photocopying, basic consumables and breakages. There are limited funds for textbooks and effectively none for a phased updating of equipment.
2. Qualitative results indicate that much of the apparatus in Scottish physics departments is 20 or more years old. An accident reported by SSERC [5] illustrates one consequence. The electric shock accident occurred when the three-pin connector on a discharge lamp had become sufficiently worn that it could be connected the wrong way around.

   "The apparatus in this accident is thought to be about 25 years old. Who of us at home continue running refrigerators, televisions or washing machines as old as that!"
3. Physics equipment budgets have not kept pace with other school costs. Many schools have had little or no growth in their equipment budgets for 20 years or more. In comparison the salary of a 'top-of-scale' unpromoted teacher was £8 472 in April 1981 but £25 644 in April 2001, an increase of 203%.

4. There is evidence that changes in teaching methodologies across the curriculum have affected equipment budgets. Twenty years ago few departments other than physics required large capital items of equipment. Now though, with the widespread use of ICT and AV equipment, those funds available for large items of equipment must be spread more widely. The rate of change of ICT equipment makes extra demands on funds as it often becomes obsolescent in five years or less. The increased use of ICT in schools has resulted in equipment budgets being spent on ICT to the detriment of traditional items such as physics equipment.
5. When a subject weighting is used in a funding formula the sciences receive smaller weightings than other practical subjects such as Technology, Home Economics and Art.
6. PTs had little direct say in budget allocations and often had little or no understanding of the method by which allocations were decided. This puts the PT in a relatively weak position to influence decision making, whichever decision making model applies. In many schools Headteachers were solely responsible for such decisions.
7. Despite the increased use of development plans in schools and the promotion of the rational decision-making model, the majority of budget allocations are not closely related to development plans and outcomes are poorly evaluated.

Recommendations

1. Central government to:
   - allocate funds in excess of SSERC recommendations so that the physics apparatus in Scottish schools can be updated within five years. These funds be 'ring-fenced' so that local authorities and headteachers cannot vire them to other competing needs. This investment in physics education will strengthen the science and engineering base of the nation for the 21st century;
   - instigate costing exercises across all subjects to determine the true cost of the teaching materials required to deliver the curriculum.
2. Headteachers to:
   - introduce programmes for the phased replacement of equipment;
   - ensure allocated funds are closely linked to development plans;
   - ensure evaluation occurs against planned educational objectives.
3. Physics teachers to:
   - be unwilling, any longer, to make do with what they have got;
   - argue strongly for sufficient resources to do their jobs properly.

References

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4 Borrows, P., *Science Departments in Secondary Schools: A Survey*, Education in Science, ASE, 1994, 157, pp24-25.

5 Electrical Accident, Bulletin 201, SSERC, 2001.

Acknowledgement

The survey was carried out and the report written by Stuart Farmer, PT Physics, Robert Gordon's College, for an MBA assessment. We are grateful to Stuart for permitting us to publish a shortened version of the report in the Bulletin.

Stuart and SSERC would like to thank the teachers who took part.

Appendix: Recommended funding allocations

Royal Society: 11-16 science taught in 6 laboratories (1997)

Total annual equipment running cost for 6 labs	£14 419.09
Equipment cost per pupil-hour	14.05p

Allowing for 4 years of inflation at 3% the figures for 2001 are

Total annual equipment running cost for 6 labs	£16 228.81
Equipment cost per pupil-hour	15.82p

The cost to teach 11-18 science, especially physics, is likely to be higher due to typically smaller class sizes post-16 and the use of expensive, specialist items of equipment.

SSERC: 12-18 physics costs per number of laboratories (August 2000)

Number of laboratories	Total annual equipment running cost
1	£7 168
2	£9 796
3	£12 424
4	£15 051
5	£17 678
6	£20 305

Staining bacterial endospores

Recent concern and resultant news coverage on the zoonosis known as Anthrax (Bacillus anthracis) provide an immediate and serious context for discussion on the occurrence and nature of bacterial endospores. A technique is described for staining the endospores of Bacillus subtilis. The practical work provides both an introduction to, and a backdrop for, discussion on the nature of resistant and long-lived bacterial spores.

Background

Anthrax is transmissible to humans through handling or consuming contaminated animal products. The causative agent of anthrax, *Bacillus anthracis*, is a spore forming, non-motile, gram-positive bacillus. Anthrax is found throughout the temperate zones of the World. It is more often a risk when animal and public health systems are ineffective. Areas currently seen as high risk are South and Central America, Southern and Eastern Europe, Asia, Africa, the Caribbean, and the Middle East. In these regions, herbivorous mammalian wildlife and livestock are at the highest risk of disease. They may become infected while grazing on contaminated land, eating contaminated feed or drinking contaminated water. Birds, amphibians, reptiles, and fish are not directly susceptible to anthrax. However, some carnivorous mammals, and omnivores such as pigs, may be susceptible to anthrax infection through consumption of meat from other infected animals.

Bacillus anthracis spores may survive for many years in contaminated soil and similar sites. For example, archaeological excavation of a mediaeval 'hospital' site at *Soutra Aisle*, in the Scottish Southern Uplands, uncovered evidence of spores of *B. anthracis* which had lain for centuries in the drains.

Anthrax is a disease transmissible from animals to man. It is therefore known as a *zoonosis*. Three forms of anthrax occur in humans: cutaneous, gastro-intestinal, and inhalational. Humans can become infected with *B. anthracis* by handling products, or consuming undercooked meat, from infected animals. Infection may also result from inhalation of aerosols containing *Bacillus anthracis* spores from contaminated animal products such as wool or the intentional, malicious, release of spores. Direct human-to-human transmission has not been reported.

Endospore staining

Because bacterial endospores are extremely resistant structures they do not absorb stains using normal methods. They therefore have to be subjected to treatment with steam to render them capable of accepting the stain.

The endospore stain is a complex staining method after which vegetative cells appear pink and bacterial endospores appear green.

Practical on bacterial endospores

Aim: To observe, under the light microscope, bacterial spores stained with Malachite Green.

Materials

- A fixed smear of *Bacillus subtilis**
- Malachite Green (HARMFUL)
- Safranin
- Immersion oil
- Water bath
- Bunsen burner
- Mat
- Microscope
- Distilled water bottle
- Blotting paper

Control measures:

- Staining rack
- Gloves
- Eye protection

* Prepare the smear from a plate culture of *B.subtilis* which has been grown on thinnish agar and is more than one week old.

Method (integrating risk controls)

1. Wear gloves and eye protection.
2. Half fill a 250 cm^3 glass beaker with water and use this as a water bath heated on a tripod over a Bunsen burner. Take care that it does not boil dry.
3. Prepare a fixed smear of *Bacillus subtilis**.
4. Place the slide of *B. subtilis* on a staining rack over the steaming water bath.
5. Flood the smear with Malachite Green and leave for 10 minutes. Make sure that the slide is being well-enveloped by the steam. Add more stain to make sure the slide does not dry out.
6. Wash with distilled water.
7. Flood the slide with Safranin.
8. Wash with water and then blot dry.
9. Examine under the microscope using the highest magnification. If possible use an oil immersion lens.
10. Make labelled diagrams of the bacteria and spores.
11. When finished, dispose of slides, gloves etc. as instructed (see HSDU issued SAPS/SSERC Techniques Cards).
12. Dispose of used slides into a discard jar with appropriate disinfectant.

Acknowledgements: The idea for this article, and the material for the practical, came from Kath Crawford, currently seconded from SSERC to the SAPS (Scotland) Biotechnology Education Project. Some of the background material came from the US Dept. of Human Health Services (www.hhs.gov/) and other 'official' websites. An illustrated version of this article will be mounted on the SSERC website as soon as pressure of work allows. See also "Sleeping Beauties" by Dr John Grainger in Issue 6 of the NCBE Newsletter, June 1997. This deals with endospores, amongst other things.

Hazardous chemicals manual - new edition

A new edition of the CD-ROM version of the SSERC publication "Hazardous Chemicals - a manual for science education" is nearing completion. Amendments and additions are described and the additional features of the new version summarised.

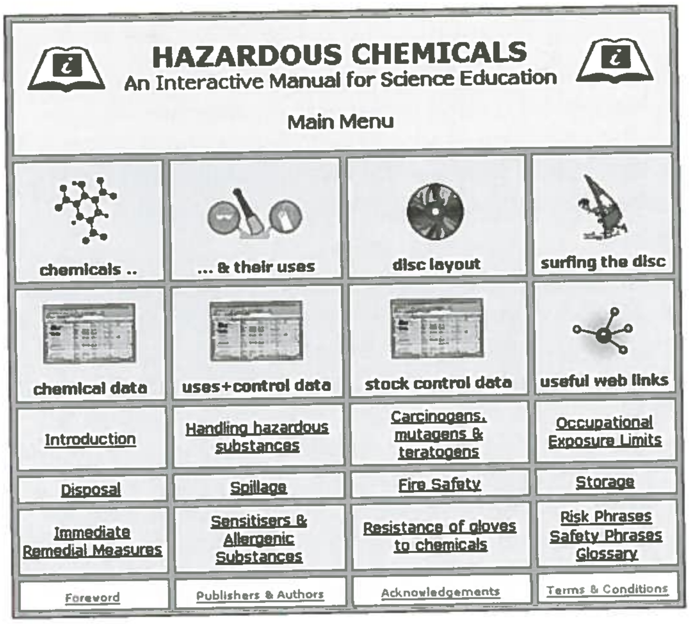


Figure 1 *New 'Main Menu' screen layout for the forthcoming second edition of the Hazardous Chemicals CD-ROM.*

As this Bulletin issue goes to press we are starting to proof read the content, and test the links, in a new edition of the CD-ROM interactive version of the 'Hazman' [as it's affectionately(?) known]. The target launch date for the second edition is January 2002 at the ASE UK Annual Meeting in Liverpool.

Allen Cochrane, Senior Associate at SSERC, and Ian Birrell our Web Designer have been working away on the new edition for many months. The results of all that work include:

- *some additional entries for chemicals not covered in previous editions;*
- *updated individual entries which take account of changes in CHIP designations and HSE EH40 publications;*
- *revised introductory sections which take account of changes in relevant legislation, and*
- *spreadsheets/databases for hazard data, risk controls and uses and stock control applications.*

Users of the CD version of the SSERC 'Hazman' will know that it uses web-based techniques to link and so cross reference the various sections and many individual entries for chemicals. The basis of sites on the web is chiefly HTML (hypertext mark up language). 'Pages' in the Hazman CD are also written in HTML. Techniques have, however, moved on amazingly in the four years or more since our first use of relatively crude HTML editing software. The ability to speak fluent nerdo-anorak is no longer compulsory.

The upshot of such general technical progress, and a great deal of hard work by the staff concerned, has been what we judge to be a vast improvement in the layout, and thus the ease of navigation, of the manual (See Figure 1 opposite). In particular, Ian Birrell has radically redesigned the manual to provide:

- *completely new main and general menu pages;*
- *'clickable' alphabetical indices and other aids to searching the entries (see Figure 2 below);*
- *'printer friendly' pages for the "Safety Data" sheets and "Uses and Control Measures" (See Figure 3).*

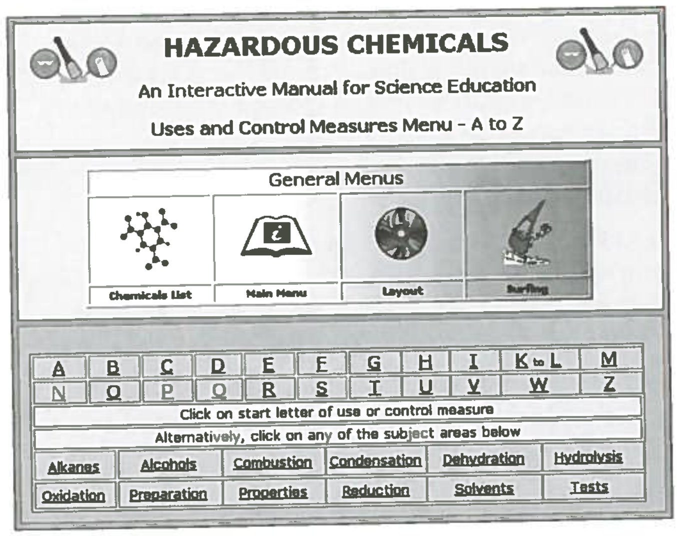
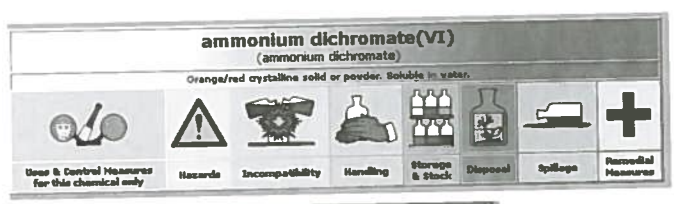


Figure 2 *'General Menu' screen for the "Uses and Controls" section. Note the alphabetical and the categories of use indices.*



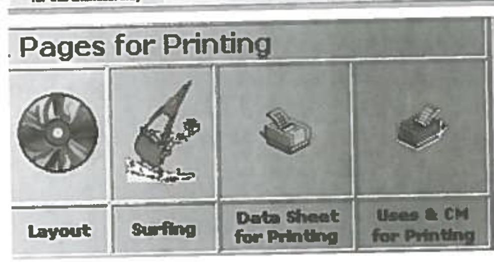


***Figure 3** Data sheet (above) and icons for print versions (left). Not to scale.*

We shall shortly fix prices for this new software. We then will be writing first to all those who have registered with us their interest in receiving updates. Network licences will be available to schools or on an authority-wide basis.

Pressure systems

This note refers to apparatus within the scope of the Pressure Systems Safety Regulations 2000 (PSSR). It includes systems with steam at any pressure, or with gas at 0.5 bar above atmospheric pressure. Autoclaves, pressure cookers, steam engines and compressed air systems fall within its scope. Vacuum systems are excluded. The care of gas cylinders falls under other regulations[1], to be discussed in a future article. But meantime, please read the safety note on an immediate need to review specifications for regulators.

The purpose is to prevent system failure and a consequential sudden release of stored energy, or the scalding effects of steam. The regulations require the employer to set up a proactive safety system with two distinct parts:

- Drawing up or certifying schemes of examination.
- Carrying out periodic examinations under the scheme.

Both parts must be carried out by a competent person – not necessarily the same person doing each part. Additionally, staff operating the pressure vessel must be given adequate instructions to work safely.

Apparatus listed in the text box opposite can, in our opinion, be adequately examined in-house with trained school technicians. Normally it should be quite straightforward. However rather than delegating these duties to their own staff, councils may choose to ask an insurance company to draw up schemes of examination and perform the examinations. Some insurance companies may insist on doing this work themselves. Compressed air systems for pneumatics equipment and model steam plant made by Cheddar should be tested by insurance companies rather than school staff.

[1] *Carriage of Dangerous Goods (Classification, Packaging and Labelling) and Use of Transportable Pressure Receptacles Regulations 1996.*

CLEAPSS have drawn up written schemes of examination. These are specific to models of autoclave, but generic for pressure cookers and model steam engines (see Table 1 below). These schemes have been kindly made available by CLEAPSS to Scottish Councils through SSERC. If a council wants to use one of these schemes then they would have to make a written declaration that they were adopting this as their own scheme of examination. The examinations could then be carried out by employees, probably school technicians, trained to do this work. The CLEAPSS guides are only so available on request to the Director of SSERC.

CLEAPSS list of pressure apparatus

Pressure cookers – models with weights

Pressure cookers – other models

Prestige steam sterilisers

Dixon's 'Express' ST18-19 aluminium autoclaves (wing-nut closure)

Dixon's 'Express' ST20-23 stainless-steel autoclaves (ratchet lid closure)

Prestige Medical 'Series 2100' autoclaves (formerly described as 'automatic electronic autoclaves')

Prestige Medical 'Omega' autoclaves

Certoclav portable autoclaves

Adelphi portable autoclaves (originally *TRF Pland* portable autoclaves)

Model steam engines

Additional Safety Note on Regulators

Please note that as from November 2001 nitrogen will be supplied in cylinders at 230 bar instead of the137 bar formerly used. You need to check that the regulator fitted to your cylinders can cope with the higher pressure. If necessary, SSERC can advise.

CLEAPSS Guide Title	Reference
Examining Autoclaves, Pressure Cookers and Model Steam Engines : Guidance for Employers	L 214a
Examining Autoclaves, Pressure Cookers and Model Steam Engines : Written Schemes of Examination	L 214b
Examining Autoclaves, Pressure Cookers and Model Steam Engines : Using Written Schemes of Examination	L 214c
Using and Maintaining Autoclaves, Pressure Cookers and Model Steam Engines	L 214d

TABLE 1 *List of four guides by the CLEAPSS School Science Service*

Trade News

Dataloggers

DCP Developments have brought out a datalogger package specifically aimed at primary and middle schools. This may be of interest for Scottish 5-14 courses in science, technology and ICT.

It's called *LogIT Explorer* and is claimed to be both PC and Mac compatible and inter-faces either via the serial port or USB. It has its own built-in light sensor with a range of other sensors also available.

For more detail see the DCP website at:

www.dcpmicro.com/

djb microtech hasn't been idle either. The promised extension of the software and sensor range into chemistry materialised over the Summer. pH and conductivity probes have been added to the existing range of sensors. The figure below shows part of a screenshot from the chemistry software with the results from an investi-gation into the *Iodine Clock Reaction*. Software for biology is scheduled for launch in November and developments are promised for 5-14 courses in 2002. See : www.djb.co.uk

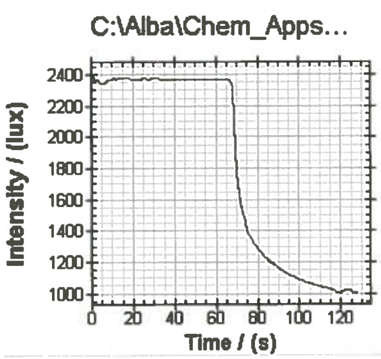


Figure 2 djb microtech chemistry software - Iodine Clock Reaction.

Science Summer Schools

The Biotechnology Summer School, sponsored by the Wellcome Trust and Unilever, will again be hosted by the University of Edinburgh in June 2002. Watch out for the relevant *flyer* which is being distributed by LTScotland. As far as we can tell at present, it looks like the Chemistry and Physics Summer Schools will also run again in 2002.

* * *

More biology hints and tips

Since the last Bulletin issue, SAPS and SSERC have each received a number of enquiries on a few missing details or bits of unclear information in some of the support material issued by, or since the demise of, the HSDU.

Buffer recipe

A recipe in one of the Advanced Higher Unit technical guides for a phosphate/ citrate buffer pH 4 provides all the necessary detail bar the molarity of the disodium hydrogenphosphate which is required. A suitable recipe for 100 cm^3 of such a buffer is 38.55 cm^3 of 0.2 M Na_2HPO_4 to 61.45 cm^3 of 0.1 M citric acid.

Lactopropionic orcein

This is listed as one of the stains required for an Advanced Higher Biology Unit viz.

"Cell and Molecular Biology : Structure, function and growth of prokariotic and eukariotic cells".

Lactopropionic orcein isn't usually listed in the catalogues under that name. Instead, see Orcein, Propionic acid eg Philip Harris Cat. No. A69849, £8.95 for 100 cm^3.

No comment

"The Times, 31st September 2026

CHEMISTS FOUND GUILTY

The *Chemistry Four* on trial for attempting to make unnatural chemicals were found guilty today in the Central Cambridge EcoCourt and each sentenced to five years hard labour at a Melchett Prison Farm. Spectators in the public gallery broke into prolonged cheering as the crest-fallen chemists, two men and two women, were led away.

The four had been reported to the Eco Police by Green Vigilantes who discovered them in the basement of the Leafield Road Eco Centre (formerly Cambridge University Chemistry Department). There they were found to have collected a number of banned chemistry books and were even attempting to make a deadly chemical, copper sulphate, using coins and a bottle of sulphuric acid which they claimed to have discovered in a disused cupboard."

* * *

Abstracted from a longer piece in the Chem@Cam 'E-zine' which is posted on :

www.ch.cam.ac.uk

With thanks to Dr W.W. Flood who first drew our attention to this piece.

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djb microtech, Delfie House, 1 Delfie Drive, Greenock, PA16 9EN. Tel/Fax: 01475 786540 E: info@djb.co.uk W: www.djb.co.uk

Philip Harris Education:

E6 North Caldeen Road, Calder Street, Coatbridge, Lanarkshire, ML5 4EF. Tel: 01236 437716, Fax: 01236 435183 and also at:

Novara House, Excelsior Road, Ashby Business Park, Ashby-de-la-Zouch, Leicestershire, LE65 1NG. Tel: 0870 6000193, Fax: 0800 7310003, W: www.philipharris.co.uk

HSE Books, PO Box 1999, Sudbury, Suffolk, CO10 2WA. Tel: 01787 881165, Fax: 01787 313995.

LTScotland, Gardyne Road, Broughty Ferry, Dundee DD5 1NY Tel: o1382 443600 Fax: 01382 443645/6 and also at:

74, Victoria Crescent Road, Glasgow, G12 9JN Tel: 0141 337 5000 Fax: 0141 337 5050.

NCBE, Whiteknights, PO Box 228, Reading RG6 6AJ Tel: 0118 987 3743 Fax: 0118 975 0140 E: NCBE@reading.ac.uk W:www.reading.ac.uk/NCBE

New Media P.O. Box 4441 Henley-on-Thames RG9 3YR UK E: info@new-media.co.uk W: www.new-media.co.uk

Nicholl Education Ltd. 4, Westleigh Hall, Wakefield Road, Denby Dale, Huddersfield HD8 8QJ E: admin@nicholl.co.uk W: www.nicholl.co.uk

SAPS Biotechnology Scotland Project, ICMB, University of Edinburgh, Darwin Building, King's Buildings, Mayfield Road, Edinburgh, EH9 3JR

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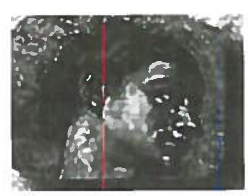
Addendum:

Michelangelo Buonarroti,

c/o The Sistine Chapel Website - www.christusrex.org.



Adam

* * *