[W1] The physics and chemistry boxes

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Many Physical Science departments are struggling to attract sufficient numbers of students and virtually all of us are also unhappy that the more able students are not choosing science for their higher and further education. This has led to the complete closure of a number of departments; a merger with cognate disciplines for some, or relegation to a 'service teaching' role for others. Despite this dramatic fall in capacity, there is still a shortfall that is a major cause of concern for all but a handful of institutions.

HOW CAN WE PERSUADE MORE SCHOOL PUPILS TO CONTINUE WITH THE PHYSICAL SCIENCES?

Surveys show that Physics students are most influenced in their choice of planned honours school by their enjoyment of the subject (87%), success in examinations (74%) and their teachers (27%). Demonstrations (9%), parents (9%), the media (4%), and their peer group (3%) were much less important. The message is clear (Norman Reid in 'Getting Started in Pedagogical Research in the Physical Sciences', LTSN Physical Sciences Practice Guide) –

> 'School experience is the dominant factor - the quality of the school syllabus and the quality of the teachers is critical.
>
> The principal area where we may have an influence, as academics, is in the perception of career opportunities.'

Nick Jagger, in a substantial document (The Right Chemistry: The choice of chemistry courses and careers, Institute for Employment Studies) re-iterates and expands on this. Some of his many points, aimed at University teachers are – Build on the public's positive attitudes to the products of chemistry. Re-claim topics such as nanotechnology for our own. Encourage teachers to use appropriate materials. Understand students' career aspirations and publicise remuneration. Develop new curricula, and be aware of changes in education. Cooperate, not compete, when responding to funding problems.

Averil Macdonald provides much valuable advice in' 'Outreach – A Guide to Working with Schools and Colleges' also available on the Centre's website. A few selected extracts are,

Produce resources for use in school
Posters, worksheets, books, homework activities, question sheets, data analysis exercises, web resources, CDROMs, datasheets, formula sheets or periodic tables etc. Despite the modern myth that people only value what they pay for, teachers love freebies. However, above all, teachers value directly useful material and will put it on the wall or use it in class.

Produce resources for use in 14-16 classes (GCSE and Standard Grade)
Teaching Resources which directly target elements of the 14 - 16 specifications will be of great use to teachers if they introduce some

cutting edge science that does not feature in text books and to which teachers may not have easy access. Supplying the material on a CDROM allows the school to network the materials.

Videos or DVDs make a popular addition to a teacher's resources but must last for less than 30 minutes (preferably in short, say 5 minute, segments) as students' attention wanders. The topic must be directly related to the curriculum and ideally a topic for which other materials are not available e.g. manufacturing processes, nuclear power, sustainable energy, astronomy, medical physics or forensic science.

Careers Materials focusing on opportunities for those with science qualifications are sadly lacking in schools. Many 14 – 16 year olds are often advised about career possibilities by people who have no background in the sciences and therefore have little idea about the range of opportunities that science opens up to them.

School-based lectures must target the specification requirements closely and be of an appropriate level – some groups will be mixed ability and not all high flyers. Lectures must also fit into the school timetable, lasting 45 minutes at most. The best lectures use a range of elements including images and practical demonstrations. Don't use a series of PowerPoint slides listing bullet point after bullet point as 15 year old students lose concentration far more quickly than conference delegates.

THE PHYSICS BOX

The Basic Challenge

How can we hope to match a school oral presentation against all of the whizzo 3D graphics in modern arcade games and compete with the specialist, creative talents now being unleashed on a multitude of TV science programmes? It seems to me that a plausible solution must incorporate a number of factors:

- We must engage the students with humour and present unusual applications of physical effects (including perhaps magic tricks), and give them simple mathematical quizzes and physical science challenges for group discussion i.e. make it fun.

- We must surprise them with reliable but spectacular effects, that they most likely have not seen or heard e.g. the frisky ping-pong ball, the latest magnetic levitation device and radio emissions from Jupiter. But also we could challenge some 'common-sense' assumptions they are likely to make and discuss the bases of pseudo-science.

- We must boost their confidence by defining simple, quick, construction projects like building a crystal set and an electric motor/dynamo, or creating their own Doppler Effect/Sonic Boom calculating device.

- We must personalise science by telling (true) stories 'warts and all' about great scientists and amateur inventors; also to include some cases of well documented scientific blunders and showing the limitations to our current knowledge.

- We must try to make interconnections across the whole of physics and into other scientific disciplines. Take some everyday effects from the home and interpret them OR modify normal conditions in a particular circumstance and show them something that then defies a simple explanation.

- We must search for the 'wow factor' or eureka moment – what natural phenomena are really going to blow their minds? For myself, the real eureka

moment was when I was a young teenager mucking about with radios and basic electronics. One day I heard 'whistlers' in Nottinghamshire when I accidentally connected a substantial earth wire to the input of an audio amplifier. I did not know what they were at the time but later, after my first degree at Imperial, I almost joined a research group based at the University of Southampton who were doing whistler research in the Orkneys.

Mathematical Limitations

The mathematics introduced should not be too difficult, but quite a lot can be done with the likes of simple formulae such as a=b/c even if we do totally disregard, say, exponentials and calculus. Remember that we are trying to get at the 'middle-of-the-roaders' who may be persuaded to study more science at AS and A levels and then hopefully consider university science courses! It would be left to the discretion of the presenter to show the student how higher level mathematics could make the explanations more complete. We would hope that our approach is consistent with the Aim Higher Initiative – we do not see the Powerpoint exemplars that will be defined in the package as dumbing-down in any sense because they are starting points for further exploration if the student's interest is aroused.

Physics Box Contents

The 'Physics Box' will consist of;

- Around 15 Exemplar Case Studies (PowerPoint presentations) on topics such as Frames of Reference and Relativity, Scale Size and Defying Gravity, Balls in Flight, Magic Tricks and Optical Illusions, The Radio Universe etc.
- Over 60 quiz/challenges on individual PowerPoint presentation slides to stimulate discussion – these will be logical, mathematical and scientific puzzles.
- Over two hundreds individual Word files containing suitable newspaper articles, short scientific texts, images, sound snippets (.WAV files), video clips, cartoons and background text relevant to GCSE level curricula.
- List of websites which are excellent resources for on-line teaching, books and articles for further reading, sources of materials for demonstrations.

Conclusion

The Physics Box is not meant to be a rigidly defined and static resource – rather it should be seen as a starting point for creating more such snippets of information or 'factoids'. These 'factoids', which can be added to the speaker's specific research activities or special interests, should help create a comfortable Powerpoint structure for each academic speaker. It presupposes that the speakers who use this resource will also have at their disposal a number of hardware components in order to demonstrate a particular effect or to persuade the students to be creative and build their own devices. Edward de Bono claimed, rather provocatively, in the Sunday Times Supplement recently (February 27th 2005) that: '*Secondary schools waste two-thirds of the student talent and our universities sterilise the remaining third'!* You may think that this is a somewhat harsh assessment of our educational system but maybe there is an element of truth. You would think that, if everything in the garden were truly rosy, we should be able to produce enough graduate physics teachers to complete the 'educational circle' – physics graduates who want to inspire the next generation of secondary school students into the beauty of our subject? I hope that this resource will help enliven some school presentations and generate enthusiasm amongst the students.

Table 1: The Presentations – Contents

Cosmetics	Food	Medicines
History	Vitamins	How medicines work
Skin	Minerals	Enzymes
Aging	Additives	Receptors
Colouring	Energy	History
Moisturisers	Dieting	Statistics
Deodorants	Proteins	Drug synthesis
Sunlight	Carbohydrates	Design strategies
Hair	Bread	Examples
Colouring	Fats	Antibacterials
'Perming'	Prostaglandins	Analgesics
Combing	Cholesterol	Amphetamines
Perfume	Margarine	Tranquilisers
Lipsticks	Chocolate	Antihistamines
Toothpaste	Cooking	Hormones
	Smells	Hallucinogens
Semiconductors	Drinks	Homeopathics
	Caffeine	Viagra, the Pill
Bonding in metals, insulators,	Fruit Juices	Abuse
and semiconductors	Alcohol	
Impurities and Dopants	Beer	
n-type and p-type	Wine	
Zone refining	Water	
Chip fabrication	'Specialities'	
Nanotechnology	Natural Food	
	Organic Food	
	Junk Food	
	Chirality	

THE CHEMISTRY BOX

In a partial attempt to address the issues covered in the introduction, The Chemistry Box consists of a series of presentations intended to provide lecturers visiting schools with some background material that explains the contributions made by chemists to modern society. It is hoped that these talks will be stimulating and excite pupils into taking the subject further at school and beyond and the contents of these lectures are aimed at helping this process. Additionally, the DVDROM contains valuable computer assisted learning material, chemical tools (such as structure drawing and a chemical calculator) and a substantial collection of videos.

The presentations are devised as complete lectures and may be used as such. They often contain animations and transitions that it is hoped will appeal to the target audience and thus these may be a bit irritating to some presenters. Notwithstanding teachers and academics are encouraged to modify them to suit their own purposes. This might involve changing the contents, using just a few slides in their own presentations or creating new presentations by amalgamating sections from several. For this reason, the files are not copy-protected in any way.

Table 2: Other Materials

Computer assisted learning modules: The Chemistry Tutor II

	Chiral molecules	Diastereomers	Conformations
	Projections	Carbonyl compounds	Aromatic substitution
	Alkenes and alkynes	Alkyl halides	
	Introduction to spectroscopy	NMR spectroscopy	
	Atomic structure	Descriptive trends in the Periodic Table	
	Numerical trends in the Periodic Table		
	VSEPR theory		
	Molecular energy storage	Elementary radioactivity	
	Gaseous equilibrium thermodynamics		
Tools	Chime: A tool for manipulating 3D structures on the web, licensed from MDL.		
	Chemical Calculator		
	Mass Calculator		
	IsisDraw: A chemical drawing program licensed from MDL.		
Experiments:	A simple Word document containing over 60 laboratory experiments suitable for schools.		
Chemical Games			
Quizzes:	A series of numerical quizzes on algebra, particles and radiation, spectroscopy, thermochemistry and volumetric titrations		
Simulations:	Programs on kinetics, moles, the Maxwell equation, particles and waves, rotations, simple vibrations and spectroscopy		
Videos:	These have been generously made freely available to education by the authors.		
	EMOL Films (samples of videos from Educational Media On-Line)		
	The Briggs-Rauscher Reaction	Convection in Liquids	
	The Creation and Destruction of Foam	The Zhabotinsky Reaction	
	The Crystallisation of Polypropylene		
	Oscillations in melamine crystal lattices		
	Three animations of vibrating molecules		
	Films from Sheffield University:		
	An Introduction to IR	*An Introduction to NMR*	
	Common Sense in the Laboratory	*Understanding Materials*	
	An Introduction to Organic Polymer Chemistry		

Liquid Air by Liverpool University.
Oxidation by Liverpool University.
Salt by Liverpool University.
Vibration Modes: Animations of vibration.
IR.avi, MS.avi, NMR.avi: Three videos on infra-red, NMR and Mass spectrometry accompanying the 'Spectroscopy' simulation program.

Waking Without Chemistry

The backbone of the series, entitled 'Waking without Chemistry' is a light-hearted look at what a school pupil might encounter upon awakening and preparing for school should there be no such thing as a chemical industry. It contains lots of sound effects, videos and fancy transitions plus a little humour. It is the only one designed to be used 'as is' although, in keeping with the philosophy of the whole series, no restrictions are placed on any desired modifications. It is perhaps the best one to give to schools for their own use since it can provide much stimulus for future debate and classroom explorations and contains very little chemistry that requires interpretation (the lecture on medicine, in particular, may need the lecturer to deal with complex nomenclature, formulae and some concepts).

'Waking without Chemistry' deals with topics such as semiconductors, electricity and lighting, polymers, electrochemistry, medicine, cosmetics, food, transport and clothing. The final part suggests a few topics that might assume importance in the future and talks about the most recent Nobel prizes in chemistry, hydrogen fuel, degradable polymers and so on.

Each item introduced by this presentation is capable of forming a whole series of lectures in its own right and some of these have been prepared and placed on the disk. Their contents are shown on the previous page.

Statistics and Studies – Contents

There are several presentations containing statistics that could be useful on a school visit plus some interesting reports. These are also put into presentation form for convenience. The figures are as up-to-date as possible at the time of preparation (Spring 2005) but, since government and other public bodies are notoriously slow, they may refer to surprisingly early dates. In a few cases, the original reports are included.

Attitudes: Public perceptions of Science and Scientists. Surveys in 2000 and 2005.

Science Careers: Typical career opportunities and remuneration.

University Admissions: Some fascinating details of admission and success rates.