Contents

Contributions on any matter of interest to second-level chemistry teachers are welcome. Normally the results of research (chemical or educational) are **not** published, except in a general form or as a review. Articles should be submitted electronically (email or disc) to **peter.childs@ul.ie** together with a printed copy.

For subscription details etc. see inside back cover.

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Cover photo: Bonawe Iron Furnace, Argyll in June 2009 - Places to Visit p.52 (Photo: P.E. Childs)

Editorial

New Year, new challenges

2011 started with a hard winter and a tough budget in Ireland. This is going to be a hard and difficult year, not least in education. There are estimated to be 100,000 graduates on the dole and emigration is in full spate again. Career prospects are not good for graduates in any subject, and this is particularly true for teachers. We have been producing a surplus of science teachers for several years now and getting a job on graduation is very difficult, even on temporary terms. Ireland's loss is the world's gain and many countries are benefiting from Ireland's economic woes. As I have said before, there are some bright spots in the gloom. The Government in 2010 committed itself to spend €2.6 billion on research over 6 years. The pharmaceutical industry is still doing well and is keeping our exports up. In January 2011 Intel announced a €500 million investment in Leixlip for upgrading one of their production plants. These are encouraging signs.

The bad weather and the deep freeze over Christmas hasn't helped morale and many people (including me) discovered firsthand that water expands on freezing and can split copper pipes. An object lesson in states of matter didn't help our collective state of mind!

It would be easy in the face of reduced pay packets, reduced public services, unemployment, and higher prices to become totally discouraged. If you are teaching and are in a job you are in a privileged position and we have a responsibility not to depress our students too much. The 1980s were actually worse on almost every measure and this was followed by the years of the Celtic Tiger. First years entering second level, if they go on to college as over 50% will do, will not be on the job market for 9-10 years! Even first years going into 3rd level in 2011 won't graduate until 2015. A lot can happen in that time and we should hope that the economy will have recovered by then. We are not preparing second level students for next year but for a decade hence and we should keep our nerve. Students entering third level won't graduate for 4 years and a lot can happen in 4 years. You know the old joke about a glass of water: the pessimist sees it as half empty, the optimist as half full. But the engineer sees a design problem – the glass was too large for its contents!

IYC 2011

This is the start of the International Year of Chemistry, which formally kicks off in Paris on 27-28th January and will be concluded on 1st December in Brussels. As well as celebrating chemistry the year also marks the 100th anniversary of Marie Curie's Nobel Prize in Chemistry. This was her second Nobel Prize and she was the first woman to win a Nobel Prize, the first to win two prizes and the first person to win two in different areas (Physics and Chemistry). In all only 14 women have won the Nobel Prize in Science since it started (see p.11). Why not do something special in your school to mark IYC2011? On p.9-11 you can find some other chemical anniversaries for 2011. If you do something for IYC2011, please take some photos and send in a report for *CinA!*

You could do something on women in chemistry, or focus just on Marie Curie. You could put on a Chemical Magic Show in the school or for local primary schools. You could visit a chemical industry or get a speaker to come into school from industry or 3rd level. You could run a poster, project, short story competition with a chemical theme. There are lots of ideas from other countries on the IYC website: www.chemistry2011.org
A global experiment on water is planned where students in many countries make measurements and share results – see http://www.iupac.org/publications/ci/2010/3205/3_wright.html for details.

Peter E. Childs
Hon. Editor

Education News and Views

Shakashiri president-elect of ACS

ACS Press Release WASHINGTON, Dec. 8, 2010 — Bassam Z. Shakhashiri, Ph.D., a chemistry professor at the University of Wisconsin-Madison, has been elected president of the American Chemical Society (ACS), the world's largest scientific society. He will serve as president-elect beginning Jan. 1, 2011, and become ACS president on Jan. 1, 2012.

"The ACS president is the most visible advocate for the chemical sciences," said Shakhashiri. "It is through chemistry research and education that we can make major contributions to improve the quality of life in America and to advance the human condition around the globe. Chemical research and technology can provide clean water and nutritious food, meet energy demands, eradicate disease, reduce poverty and help lead to sustainable development everywhere."

Bassam Z. Shakhashiri, Ph.D., a chemistry professor at the University of Wisconsin-Madison, Madison, Wis., was elected president of the American Chemical Society board of directors. Credit: American Chemical Society

Shakhashiri's priorities also include assuring support for research and education, promoting green chemistry, helping the public understand the science of climate change, addressing employment issues and fostering international cooperation and collaboration in research and education.

Shakhashiri joined ACS in 1962, and has won many honors, including the ACS Chemical Education Award in 1986 and the Helen M. Free Award for Public Outreach in 2005, for "lifelong accomplishments and for explaining and demonstrating science with charisma and passion." In 2002 he received the American Association for the Advancement of Science Award for Public Understanding of Science and Technology, "for his tireless efforts to communicate science to the general public, and especially children." In 2007 he received the National Science Board Public Service Award and was cited for "extraordinary contributions to promote science literacy and cultivate the intellectual and emotional links between science and the arts for the public." Shakhashiri has given more than 1,300 invited lectures and presentations in North America, Europe, Asia, Australia, the Middle East and South America.

He received his A.B. from Boston University in 1960, his M.Sc. from the University of Maryland in 1965 and his Ph.D. in 1968. Shakhashiri is the first holder of the William T. Evjue Distinguished Chair for the Wisconsin Idea at the University of Wisconsin-Madison, where he has been a professor since 1970. In 1983, he was the founding director of the Institute for Chemical Education, and from 1984 to 1990, served as an assistant director of the National Science Foundation (NSF). There he presided over rebuilding and re-launching NSF efforts in science and engineering education, after they had been essentially eliminated in the early 1980's. In 2001, he founded the Wisconsin Initiative for Science Literacy, with the goal of promoting literacy in science, mathematics and technology among the general public and to attract future generations to careers in research, teaching and public service.

Stop press: Bassam Shakashiri has agreed to give the Viktor Obendrauf Memorial Demonstration Lecture at the 22 ICCE/11 ECRICE joint conference in Rome 15-20 July 2012.

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2009 PISA results

On Dec.7th 2010 the results of the 2009 PISA survey were published. These results provide a triennial opportunity for reflection on educational standards. Ireland didn't fair too well in 2009: its performance dropped in Reading and Maths and held its own in Science. The 2009 study focused on Reading. The 2006 study focused on Science and in 2012 Mathematics will be the main focus. The domains covered since 2000 are shown below in Table 1.

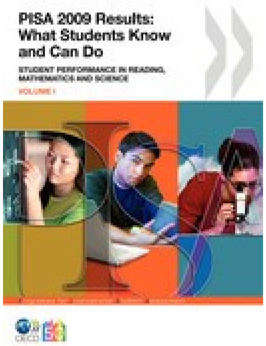

Table 1 Domains used in the PISA surveys

Cycle	Major Domain	Minor Domains
PISA 2000	**Reading**	Mathematics, Science
PISA 2003	**Mathematics**	Reading, Science, cross-curricular problem-solving
PISA 2006	**Science**	Reading, Mathematics
PISA 2009	**Reading**	Mathematics, Science
PISA 2012	**Mathematics**	Reading, Science, cross-curricular problem-solving

Ireland's involvement is coordinated by the Educational Research Centre, Drumcondra (http://www.erc.ie/?p=55/) and work is already underway on the firth cycle in 2012.

The full report can be accessed at the OECD website as well as an Executive Summary. http://www.pisa.oecd.org/document/61/0,3746,en_32252351_32235731_46567613_1_1_1_1,00.html The *At a glance* report is a very accessible summary: **http://www.pisa.oecd.org/dataoecd/31/28/46660259.pdf**

"Around 470 000 students participated in PISA 2009, representing about 26 million 15-yearolds in the schools of the 65 participating countries and economies. Some 50 000 students took part in a second round of this assessment, representing about 2 million 15-year-olds from 10 additional partner countries and economies.

The main focus of PISA 2009 was reading. The survey also updated performance assessments in mathematics and science. PISA considers students' knowledge in these areas not in isolation, but in relation to their ability to reflect on their knowledge and experience and apply them to real-world issues. The emphasis is on mastering processes, understanding concepts and functioning in various contexts within each assessment area.

For the first time, the PISA 2009 survey also assessed 15-year-old students' ability to read, understand and apply digital texts."

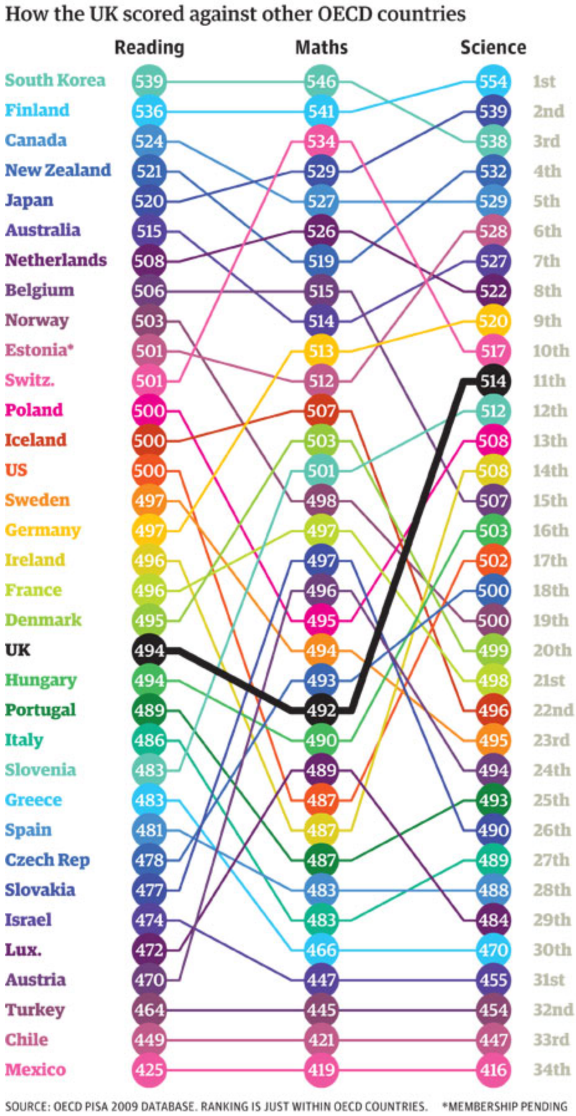

Figure 1 2009 PISA scores

Table 2 Ireland's performance 2000-2010

Year	Reading	Maths	Science
2009	496	487	508
2006	517	501	509
2003	515	503	505
2000	527	503	513

It is clear from this that Science is holding its own, remaining above the OECD average. However, both Reading and Maths have declined since 2000 and are now below average, and Ireland is slipping down the table.

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New Pharmachemical ISTA award

The awards for new science teachers sponsored by Pharmachemical Ireland through the ISTA, which have been run for the last 3 years, have changed in 2011. From this year the award will be open to any Irish science teacher, not just new teachers. Details are given on p. 7.

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Nanonet Ireland launched

A new organisation, Nanonet Ireland, has been launched to link people working in nanoscience from both academia and industry. The slogan of the new body is "Small Science. Big Impact". Nanonet is organising the first Nanoweek from Jan. 31st. to Feb. 4th., aimed at promoting an awareness of nanoscience and its importance to the Irish economy.

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Science film festival promoted in 2012

Irish Times 19/1/11

University College Dublin is promoting a festival of science films for July 2012, to coincide with Dublin's time as European City of Science. UCD has linked up with Imagine Science Films who have run a similar annual festival in New York for the past three years. (www.imaginesciencefilms.com)

A whole series of science events are being planned for Dublin in 2012 and you can get details at: www.c-s.ie/cityofscience2012/

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National Strategy for Higher Education

Hunt Report published at last

The long-awaited Hunt Report on the future of Higher Education was published on the 11th. January, to a muted fanfare. It was over a year late and had been comprehensively leaked beforehand. The news that hit the headlines was the recommendation for student fees and most commentators seemed to think the Report was a damp squib – long on generalisations and promise and short on specifics and actions. Just as academics at 3rd level should know what is happening in schools, so school teachers should know what is happening in higher education, since this is where many of their students will end up. The Report also recommended that institutes of technology might combine to form technological universities (and four several ITs are already in discussions) and that the HEA should continue to oversee higher education. The Report may well end up in the government's dusty collection of shelved reports, especially as the present government has only a few weeks to run.

The report is available online and a summary of the recommendations is given on p.8-9.

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Winners of ISTA Senior Science Quiz 2010

Mary Mullaghy

Thank you to everyone who participated in the Final of the ISTA Senior Science Quiz held in **Trinity College** on **Saturday 27th November** and a special thanks to **Aoibhinn Ní Shúilleabháin** who was the celebrity guest quizmaster. Details of the Winners is now posted under NEWS on www.ista.ie.

Despite snowy weather 30 out of 32 teams showed up for the Final. Mr Matt Moran, Director of PharmaChemical Ireland and current President of ISTA launched the new PharmaChemical Ireland ISTA Awards for teachers 2010.

Mary Mullaghy (R, ISTA) making a presentation to Aoibhinn Ní Shúilleabháin (L)

The quiz was generously sponsored by PharmaChemical Ireland, with cash prizes going to the first five teams ranging from €200 to €50 per team member. The Royal Society of Chemistry sponsored the hiring of the venue. Thanks to all ISTA members who attended the quiz and to those who helped out at the event and a special thanks to all the teams and their teachers who travelled from all over Ireland.

It was a tightly fought competition. Four teams tied for first place so after tie breakers the following were the eventual winners.

1. St Mary's College, Galway.
2. St MacCartan's College, Monaghan.
3. Summerhill College, Sligo
4. Blackrock College, Dublin.
5. Christian Brothers Secondary School, Nenagh, Co Tipperary.

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The Mallow Schools Project

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The National Centre for Excellence in Mathematics and Science Teaching and Learning (NCE-MSTL) and the Mallow Development Partnership group launched a joint Schools Project on October 2010 and formally signed agreements at an event in the University of Limerick on January 11th 2011. This is a unique project and represents a key strategic initiative for Mallow and a platform for the future, in giving the Mallow schools the opportunity to be the leading school district in a strategy to address science and mathematics teaching and learning nationally.

The four year project involves the primary and second level schools in Mallow and district and aims to increase achievement levels in science and mathematics at primary level, Junior Cycle and Senior Cycle and in particular the physical sciences and higher level mathematics.

The NCE-MSTL and the Mallow schools' teachers are engaged in continuing professional training, which is focusing on science and mathematics knowledge and pedagogy knowledge. Action research is planned to commence in the near future, which will give teachers an opportunity to be collaborative researchers and to register for a master's post graduate qualification should they wish to do so.

The teachers' involvement in the on-going continuing professional development (CPD) and in the researching of new practices is enabling engagement, sharing of information and the development of peer-support and collaboration. Through these actions a community of practice in the district is being created, which in the long term will help sustain and embed new practices in schools and research amongst teachers, and will contribute to the development and enhancement of students' understanding of mathematics and science on an ongoing basis.

The NCE-MSTL is a mathematics and science teaching and learning research and support centre, located in the University of Limerick. The National Centre's mission is to address issues in the teaching and learning of science and mathematics nationally by conducting best practice, evidence based research into teaching and learning in mathematics and science, and co-ordinating, developing and implementing programmes to enhance Irish Science and Mathematics Teaching and Learning from Primary, to Secondary, to third and fourth levels. Details of its activities and publications can be found at: www.nce-mstl and teachers need to register to access all the facilities.

The National Centre also produces a series of Resource & Research Guides (RRG), which are sent in printed form to schools and are also available free-of-charge on the website. Volume 1 (produced in 2009-10) consisted of 14 RRGs. The first batch of 5 titles was sent out in the first term 2010-11 and the second batch of Volume 2 will be published in February 2011. The RRGs cover a range of topics in the teaching and learning of science and mathematics, and seek to communicate the findings of research to the practising teacher. Your comments on the Guides and suggestions for future topics would be welcome.

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5th Chemistry Demonstration Workshop at UL

This year's Chemistry Demonstration Workshop at the University of Limerick will run from June 13th to 17th. June and will cost €100. The rest of the costs are subsidised by the sponsors. It is a residential course and places are limited. For more details contact sarah.hayes@ul.ie and ask for a booking form. To reserve a firm place you need to send in your fee with the form, but this will be refunded if the course is cancelled or you can't come. This workshop has run successfully for 4 years and over 40 teachers have been trained.

□

PharmaChemical Ireland's Industry Awards for Science Teaching Excellence 2011

Siobhán Murphy, Pharmachemical Ireland Siobhan.murphy@ibec.ie

Pharmachemical Ireland, the sector in IBEC hat represents the Irish pharmaceutical and chemical industry, has launched the 2011 Industry Awards and invites applications.

Now in their fourth year, these awards recognise excellence in the teaching of science. The last three years saw a range of winners, all just graduated from university and in their first years of teaching. They continue to demonstrate excellence in their teaching and motivate their students to pursue a career in science. Siobhán Murphy, education executive with PharmaChemical Ireland, said *"Never before has innovation in the science teaching profession been so important. In announcing the industry awards for 2011 PharmaChemical Ireland signals the value that the industry places on science education and on the teachers who strive to innovate in the classroom. Such enthusiastic science teachers are crucial to the development of the sector and to the future employment needs of the pharmachemical industry"*

The 2011 awards

This year the awards are open to the entire science teaching community. From mid October to the end of February, 2011, ISTA members currently teaching science at post-primary level their local branch between now and the end of February. An electronic copy of this presentation along with evaluation forms, attendance roll and a completed application form should be forwarded to Siobhan Murphy. The top four entries will be required to give their presentation at the ISTA Conference in April 2011, at which an overall winner will be selected.

Application forms and guidelines can be downloaded from the ISTA and PharmaChemical Ireland websites: www.ista.ie and www.pharmachemicalireland.ie.

The winners will be announced at the Irish Science Teachers' Association annual conference in Thurles in April 2011. The runner up will receive two years membership of the ISTA, an LCD projector and a cash prize of €500.
The overall winner will receive a prize of ten years membership of the ISTA, a laptop computer and a cash prize of €1,000.

Entry Details

1. The awards will run from mid October 2010 to the end of February 2011.

2. Application forms and guidelines can be downloaded from the ISTA website.

3. A hard copy of the computer presentation delivered at the branch meeting must be included in the entry.

4. An electronic copy of the computer presentation should be emailed to siobhan.murphy@ibec.ie

5. An evaluation form should be completed by all the members of the branch who attend the presentation.
These evaluation forms should be included with the applicant's entry. (A copy of the evaluation form can be downloaded from www.ista.ie)

6. All entries should be forwarded to:
Ms Siobhán Murphy, PharmaChemical Ireland, Confederation House, 84-86 Lower Baggot Street, Dublin 2, before the 28th February, 2011.

7. The top four entries will be required to deliver their presentations at the ISTA Conference in April 2011, at which an overall winner will be selected.

□

Hunt Report on a National Strategy for Higher Education until 2030

Published January 11 2011

Available online at: http://www.hea.ie/en/strategy-for-higher-education

The full report can be read online and the summary of the recommendations is given below.

Summary of Recommendations

1 Higher education students of the future should have an excellent teaching and learning experience, informed by up-to-date research and facilitated by a high-quality learning environment, with state-of-the-art learning resources, such as libraries, laboratories, and e-learning facilities.

2 Higher education institutions should put in place systems to capture feedback from students, and use this feedback to inform institutional and programme management, as well as national policy.

3 Every student should learn in an environment that is informed by research, scholarship and up-to-date practice and knowledge.

4 The Irish higher education system must continue to develop clear routes of progression and transfer, as well as non-traditional entry routes.

5 Higher education institutions should prepare first-year students better for their learning experience, so that they can engage with it more successfully.

6 Both undergraduate and taught postgraduate programmes should develop the generic skills needed for effective engagement in society and in the workplace.

7 In light of the scale of transformation in teaching and learning that is under way in Irish higher education, the quality assurance framework must be reviewed and further developed.

8 All higher education institutions must ensure that all teaching staff are both qualified and competent in teaching and learning, and should support ongoing development and improvement of their skills.

9 Investment in R&D should be increased.

10 The researcher's role should be afforded a wider focus, better mobility and increased career opportunities.

11 A consistent quality framework should be developed for Irish PhD education, based on critical mass.

12 Public research funding should be prioritised and better coordinated and underpinned by effective foresight, review and performance measurement systems.

13 Knowledge transfer should be better embedded into institutional activity and rewarded accordingly. The commercialisation of intellectual property from publicly-funded research should primarily provide a gross return to the economy.

14 Engagement with the wider community must become more firmly embedded in the mission of higher education institutions.

15 Higher education institutions should set out their international vision in an institutional strategy.

16 Higher education institutions should put in place appropriate supports to promote the integration, safety, security and well-being of international students.

17 Ireland's autonomous institutions should be held accountable for their performance to the State on behalf of Irish citizens.

18 Governance structures should be reformed at both institutional and system levels.

19 A framework should be developed to facilitate system-wide collaboration between diverse institutions.

20 The institute of technology sector should commence a process of evolution and consolidation; amalgamated institutions reaching the appropriate scale and capacity could potentially be re-designated.

21 Smaller institutions should be consolidated to promote coherence and critical mass.

22 The current employment contracts for academic staff must be reviewed with a view to recognising academics' professional standing and requiring comparable levels of accountability to those in place in the wider public and private sectors.

23 Over the lifetime of the strategy and in the context of a reducing reliance on the exchequer, individual higher education institutions will progressively take on greater responsibility for key human resource functions.

24 The funding base for higher education must be broadened through the reform of student financing, including a new form of direct student contribution based on an upfront fee with a deferred payment facility.

25 The growth of higher education must be sustainable and resourced with an appropriate funding base. Growth and quality improvement must be progressed together.

26 Public investment in higher education must be aligned with national policy priorities, including widening of access, enhanced performance outcomes, and greater flexibility in provision.

You can find out what events are planned worldwide during the year at: http://www.chemistry2011.org/participate/events

Need ideas to celebrate a science anniversary in 2011?

Idea by Fabienne Meyers on the IYC website (added on Dec 14, 2010 05:04PM)

Here are just a few key anniversaries in 2011 from the *The Timetables of Science*:

25th anniversary of: [in 1986]

- Dudley R. Herschbach and Yuan T. Lee, inventors of the crossed-beam molecular technique, and John C. Polyani, inventor of chemiluminescence as a way of studying chemical reactions and bonds, win the Nobel Prize for Chemistry
- K. Alex Müller and J. Georg Bednorz discover an oxide combination that is superconducting at 30 degrees Kelvin, the highest known temperature for superconductivity
- Heinrich Rohrer and Gerd Binnig and Ernst Ruska share the Nobel Prize for Physics, Ruska for designing the first electron microscope and Rohrer and Binnig for designing the scanning tunneling microscope

50th anniversary of: [in 1961]

- Melvin Calvin wins the Nobel Prize for Chemistry for his work on the chemistry of photosynthesis
- The artificial element 103, lawrencium, is produced by a team led by Albert Ghiorso
- Marshall Warren Nirenberg works out the first "letter" of the genetic code
- Robert Hofstadter discovers that protons and neutrons have a structure

75th anniversary of: [in 1936]

- Catalytic cracking is developed for refining petroleum
- Peter J.W. Debye wins the Nobel Prize for Chemistry for his study of dipolar moments
- Robert R. Williams synthesis vitamin B1 (thiamine)
- Erwin Wilhelm Mueller develops the field-emission microscope
- introduction of fluorescent lighting

100th anniversary of: [in 1911]

- Thomas Hunt Morgan begins to map the positions of genes on chromosomes of the fruit fly
- Alfred Henry Sturtevant produces first chromosome map showing five sex-linked genes
- William Burton introduces thermal cracking of refining petroleum
- Chaim Weizmann discovers how to obtain acetone from bacteria involved in fermenting grain
- Niels Henrik Bohr makes his first attempt to link atomic structure to Planck's constant
- Heike Kamerlingh Onnes discovers superconductivity in mercury cooled close to absolute zero
- Ernest Rutherford presents his theory of the atom, consisting of a positively charged nucleus surrounded by negative electrons
- Frederick Soddy observes that whenever an atom emits an alpha particle, it changes to an element two places down in the list of atomic masses
- Marie Curie wins the Nobel Prize for Chemistry for her discovery of radium and polonium
- Wilhelm Wien wins the Nobel Prize for Physics for determining the laws of radiation of black bodies
- The first Solvay conference is held, bringing together many of the physicists involved in the new study of the atom

125th anniversary of: [in 1886]

- Simultaneous discovery of the electrolytic process for extracting aluminium by American chemist Charles Martin Hall and French scientist Paul Héroult.

150th anniversary of: [in 1861]

- William Crookes discovers thallium as a bright green line in the spectrum of a selenium ore he is investigating; thallium means "green twig"
- Gustav Kirchhoff and Robert Bunsen discover a bright red line in a spectrum that represents a new element, which they name rubidium for "red"
- Ernest Solvay discovers a process for making sodium bicarbonate from salt water, ammonia, and carbon dioxide, which is much more economical than preceding processes

200th anniversary of: [in 1811]

- Amedeo Avogadro, Comte de Quarenga, proposes that equal volumes of any gas at any given temperature and pressure always contain an equal numbers of molecules (Avogadro's law)
- Jöns Jakob Berzelius introduces a system of chemical symbols that forms the basis the system used today
- Bernard Courtois discovers the element iodine in seaweed, but does not recognize it as a new element; it is so recognized by Humphry Davy in 1814
- Gottlieb Sigismund Constantin Kirchhoff prepares glucose by heating starch with sulfuric acid
- Louis-Nicolas Vauquelin discovers uric acid in the excrement of birds
- Samuel Hahnemann publishes a catalogue of homeopathic drugs
- François Arago discovers optical activity of quartz
- Simeon-Denis Poisson develops a mathematical theory of heat based on the work of Jean-Baptiste Fourier

250th anniversary of: [in 1761]

- Joseph Black discovers latent heat

350th anniversary of: [in 1661]

- Publication of Boyle's *The Sceptical Chymist* introduces the modern concepts of element, alkali, and acid and refutes many of the ideas of Aristotle and

Paracelsus on the chemical composition of matter

400th anniversary of:

- Johannes Kepler's A new year's gift, or On the six-cornered snowflake is the first published description of the hexagonal nature of snowflakes in the West, although this characteristic was known earlier in China.
- Marco de Dominis publishes a scientific explanation of the rainbow

Reference: *The Timetables of Science – A Chronology of the Most Important People and Events in the History of Science*, by Alexander Hellemans and Bryan H. Bunch, 1988, published by Simon and Schuster (ISBN 067162130-0)

Nobel Prize-Awarded Women in science and medicine

http://nobelprize.org/nobel_prizes/lists/women.html

The Nobel Prize and Prize in Economic Sciences have been awarded to women 41 times between 1901 and 2010. Only one woman, Marie Curie, has been honoured twice, with the 1903 Nobel Prize in Physics and the 1911 Nobel Prize in Chemistry. This means that 40 women in total have been awarded the Nobel Prize between 1901 and 2010.

The Nobel Prize in Physics

1963
Maria Goeppert-Mayer
1903
Marie Curie

The Nobel Prize in Chemistry

2009
Ada E. Yonath
1964
Dorothy Crowfoot Hodgkin
1935
Irène Joliot-Curie
1911
Marie Curie

The Nobel Prize in Physiology or Medicine

2009
Elizabeth H. Blackburn
2009
Carol W. Greider
2008
Françoise Barré-Sinoussi
2004
Linda B. Buck
1995
Christiane Nüsslein-Volhard
1988
Gertrude B. Elion
1986
Rita Levi-Montalcini
1983
Barbara McClintock
1977
Rosalyn Yalow
1947
Gerty Cori

Motivating and Engaging Chemistry Students – Achievable Goal or Holy Grail?

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Introduction

Since 2001, a number of initiatives have been introduced at Dublin Institute of Technology (DIT) with the intention of supporting the learning of chemistry undergraduates as well as encouraging interest and engagement in the subject.

The main elements have been;

- development of effective learning support for first years, particularly those who have not studied chemistry before. This included restructuring of weekly tutorials to become problem solving workshops and the development of a Virtual Learning Environment (VLE) incorporating resources and online self assessment quizzes with instant feedback
- introduction of contextualised laboratory practicals (in forensic chemistry)
- development of project-based learning laboratory practicals (in spectroscopic analysis and organic synthesis/medicinal chemistry)
- introduction of community-based learning assignments involving interaction with local secondary schools and organisations. Examples include supporting outreach events such as Chemistry at Work and performing alcohol analysis on samples from student volunteers as part of a Garda road safety awareness campaign
- incorporation of eLearning into the curriculum where appropriate, including the use of online discussion boards, wikis and interactive resources incorporating video clips

Evaluation of the changes implemented has been performed and the extent to which the aim of motivating and engaging students has been achieved has been examined.

Underlying Principles

Three important principles underpin the approach that has been taken. They are as follows;

- The incorporation of **active learning** and an emphasis on what the students does rather than what the teacher does;
- Careful **assessment design** to ensure that all of the learning outcomes are being assessed;
- Adoption of a **scientific approach** to science education. This involves encouraging staff to approach their teaching in the same that way they carry out their research, *i.e.* to evaluate new methodologies and to experiment from time to time.[1] Another important feature is the design of teaching methods and development of the curriculum based on evidence available from education research. A significant recent development is the research by Reid[2] and Johnstone[3] investigating how learners in chemistry process new information. This work incorporates the important concepts of working memory and cognitive overload.

The Chemical Education Research Team (CERT) was established in DIT in 2005 with the aim of incorporating best practices in emerging education research into our day-to-day teaching.[4] Much of the work described in this article has been undertaken in collaboration with my fellow CERT members: Dr Christine O'Connor, Dr Sarah Rawe and Dr Michael Seery.

Strategies Implemented at DIT to Motivate and Engage Chemistry Students

1. Learning Support for First Year Chemistry Students

Two significant trends occurring in Ireland over the past two decades have been the decrease in the percentage of students taking chemistry as a Leaving Certificate subject (21% in 1987, 14% in 2005, 12.5% in 2010) and the increase in the level of participation at third level (46% of second level students progressed to third level in 1991, 55% did so in 2005). This has resulted in a change in the type of learners entering third level. The new cohort of students are distinct from the traditional intake in that they are generally not very well-prepared for higher education and may often not know many friends or family members who have experienced education at third level. Thus they do not know what to expect or what will be expected of them. Also, they will more than likely not have studied chemistry or higher level maths. These factors combined mean that they often perceive chemistry to be a difficult subject and may expect to fail or to do poorly in it from the outset. Cottrell has argued that the different type of learners entering our colleges and universities must be taught using different methods to those used in the past. She has stated that higher education institutions;

> *"are slowly realising that it is not simply enough to open the doors: what goes on behind the doors has to change to accommodate new types of student intake."* [5]

She also points out that one of the positive outcomes of this situation is that good teaching skills are now valued and there is an impetus to examine and to implement some different teaching and learning strategies to support these students.

The strategies implemented at DIT to scaffold learning for first year undergraduates since 2001 are listed below:

- Viewing induction as a year-long process
- Incorporation of visual images
- Contextualisation
- Demystification of the marking process
- Making lab experiments more relevant and engaging
- Hands-on use of molecular models
- Introduction of interactive activities
- Assessment tasks that encourage creativity
- Incorporation of e-learning methods
- Focus on active learning (problem-solving workshops)

This work was undertaken in collaboration with Dr Christine O'Connor and further details on each strategy are available in previous publications.[6,7] These changes have been shown to have improved retention and exam pass rates. The two that were most significant were found to be the introduction of problem-solving workshops and of a virtual learning environment. Chemistry tutorials were modified to become problem solving workshops where the students are actively learning and often engaged in peer-mentoring. Tutors act as facilitators and a room with non-fixed seating is used to encourage students to work together if they need to. In 2004, a virtual learning environment (VLE) was developed using WebCT software.[8] The approach used was to pool all existing electronic format resources (summaries, useful websites, sample questions, crosswords) provided by staff teaching first year undergraduates as well as the preparation of formative assessment multiple choice quizzes with instant and detailed feedback for self-directed learning. As an incentive to use these quizzes, an assessment towards the end of the year is based on these quizzes.

2. Context-based Lab Practicals

This strategy involves maintaining the original core chemistry content of the lab practicals but contextualising them according to the learner's particular degree choice. Funding was obtained from the Higher Education Academy Physical Sciences Centre and a series of first year practicals were modified to provide a forensic chemistry context by the DIT Chemistry Education Research Team (CERT) in collaboration with Dr Sarah Cresswell from the University of Strathclyde.[9] The labs developed and the chemical principles they address are summarised below;

i) Fingerprinting Laboratory – Volatility, adsorption, material types and porosity, polymerisation, chemical staining, fluorescence.
ii) Identification of Poisons – Anion and cation testing, inorganic reactions, atomic emission (flame photometry) and wet chemistry analysis.
iii) Cheque Forgery – TLC of inks, solvent polarity and extraction techniques.

3. *Project-based Learning and Research-oriented Approaches in the Lab*

In 2005, project-based learning laboratory projects in Spectroscopic Analysis were introduced for second years students.[10] Groups of two or three learners were each assigned a mini-research project and they were given five sessions of three hours to work on it over which time they had to select a suitable method of analysis and devise their own procedures. For example, one project involves the identification and quantification of the ingredients in a herbal remedy for baldness. The approach used differs significantly from traditional labs and a diagrammatic comparison between the two is provided in Figure 1 below. The underpinning rationale is to provide a means to develop generic/transferable skills such as problem solving, team work, development of scientific method and communication.

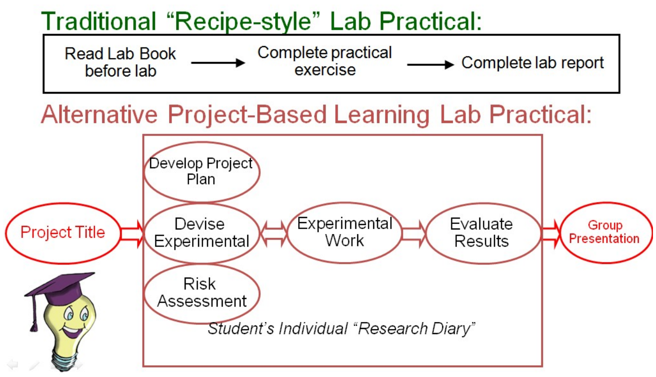

Figure 1: Comparison of the processes involved in a traditional laboratory practical with those in a project-based learning practical.

In 2008, a project-based learning activity was implemented for third year Medicinal Chemistry practicals in which students in groups of two were provided with a journal article which included experimental details on the synthesis of a molecule of biological interest (*e.g*. an analogue of Prozac) and were required to synthesise and characterise the molecule and work out the cost of producing it. This work was undertaken by the DIT Chemistry Education Research Team led by Dr Sarah Rawe and in collaboration with Prof Simon Belt from the University of Plymouth. Funding was provided by the Royal Society of Chemistry (Chemistry for our Futures project).

These project-based learning projects can also be described as "research-oriented" as this term is defined by Elsen *et al.*[11] to involve activities that are "focused on learning the processes of knowledge construction in the subject by practicing research activities". An initial evaluation of the project-based learning labs based on some short pre- and post- surveys, informal discussions and reflective writing assignments submitted by students showed that the majority of learners preferred these labs to the more traditional ones and that their engagement (based on attendance figures for lectures and labs) had improved.[10] A more thorough evaluation which focuses on whether the learners are better prepared to undertake individual final year research projects is ongoing and it is expected that the results will be published in late 2011 (Research Awareness and Readiness Evaluation project, funded by National Academy for Integration of Research, Learning and Teaching).

4. *Community-based Learning*

Community-based learning (CBL) is also known as service learning and this pedagogical approach has been implemented in chemistry courses at DIT since 2007. Bringle and Hatcher provide a detailed definition of what is involved[12] but perhaps the easiest way of introducing the concept is to describe it as something in between student volunteering and a placement. A project should address a genuine community need and it should be designed so that students meet course-related learning outcomes and receive academic credit for their work. Students are also required to reflect on their learning as part of the process. This pedagogy is very well-established in America at second and third level and further information and examples of community-based learning in practice are available from several websites.[13] The approach used when initially implementing these projects in DIT was to examine assessments already used in existing modules and to examine how they might be modified to the benefit of community partners.

Second year students are involved in community-based learning projects as the practical component of their Professional Skills module. The learning outcomes and project structure are summarised in Table 1 below.

Year 2, B.Sc. Medicinal Chemistry and Pharmaceutical Sciences - Professional Skills.	
Learning Aims	To develop information literacy, communication and teamwork skills.
Learning Objectives	1) Design and plan a scientific poster presentation and/or demonstration to communicate an understanding of the application of chemistry in everyday life to second level students. 2) Find and retrieve information for the poster/demonstration. 3) Present the posters and/or perform demonstrations during an outreach event and reflect on the assignment.
Additional Information	Students assigned to groups of 2-3, online discussion boards used for progress reports and queries.
Assessment Components	Presentation and/or demonstration (group). Contribution during lab sessions and to discussion board. Project diary. Reflective writing assignment.
Weighting	40 % of module mark
Student Learning Hours	15 to 18 contact hours and 20 hours independent study
Number of Students	45 over 4 academic years

Table 1: Summary of components of community-based learning project for Year 2 Professional Skills module.

In 2007 and 2008, the students helped to organise a Royal Society of Chemistry event in DIT for secondary schools called Chemistry at Work. This required them to liaise with professional scientists who were speaking at the event and to prepare suitable demonstrations and scientific posters that were relevant to the speaker's topic. In 2009 and 2010, it was not possible to run the Chemistry at Work event for logistical reasons. Instead, a collaboration with a local secondary school, Synge St. CBS, was initiated and assistance on a number of topics specified by their teacher was provided to a group of senior cycle chemistry students. Communication was by means of a Google Groups online discussion board and the secondary school students also visited DIT for an afternoon and the DIT students provided relevant demonstrations, presentations and posters. In 2010, the DIT students also took part in a lab session in the school which provided an excellent opportunity for them to interact with the second level students.

Year 4, B.Sc. Forensic and Environmental Analysis - Chemical Control, Radioactivity and Bioinorganic Chemistry Module	
Learning Aims	To acquaint the student with requirements of the legislation on to the use of chemicals in the workplace and how compliance is achieved and to develop teamwork and organisational skills.
Learning Objectives	1) Appreciate the requirements of the health and safety legislation in relation to the work environment. 2) Have a working knowledge of the specific legislation pertaining to the 'use' of chemicals in the work place. 3) Undertake a chemical risk assessment and use chemicals safely in the workplace. 4) Develop group work and organisational skills.
Additional Information	Students work in groups of 3-4 and select their groups themselves. They perform chemical risk assessments and safety audits in small businesses.
Assessment Components	Project plan (group). Presentation (group). Report (group). Reflective writing assignment.
Student Learning Hours	8 contact hours and 40 hours independent study
Weighting	60% of module
Number of Students	103 over 4 academic years

Table 2: Summary of components of community-based learning project for Year 2 Chemical Control, Radioactivity and Bioorganic Chemistry module.

Fourth year students at DIT have been involved in community-based learning projects as the practical component of their Chemical Control module. The students, in groups of three, are required to contact a small business (e.g. a garage or hairdressers) and arrange to perform a safety audit and chemical risk assessment on a process undertaken there (e.g. spray-painting a car, colouring hair). The main components of this project are summarised in Table 2 above.

Since 2008, another project with second year students on another degree course (B.Sc. Forensic and Environmental Analysis, DT 203) has been established in collaboration with Ms Leslie Shoemaker. The students are assigned to groups of 2 or 3 and they visit local secondary schools that have expressed an interest and give a presentation entitled Studying Science and College Life. The students send a confirmation letter to the school and prepare the presentation. They are accompanied by a staff member who marks their presentation.

The DIT Students Learning With Communities office was established in 2008 and, since then, has provided a very useful means of putting community groups in contact with academic staff from relevant disciplines. Several cross-disciplinary projects have developed as a result.[14] One involves education of college students on road safety awareness and chemistry students have contributed by conducting alcohol testing on student volunteers the morning after they have been out drinking alcohol socially. Another, the Lifeline project, is an investigation of how to use disused green spaces in Dublin city effectively and chemistry students have undertaken soil analysis for organic and inorganic contaminants under the supervision of Dr Barry Foley.

Evaluation of the community-based learning projects by means of student evaluation forms and reflective statements has shown very positive results. It was found that students value the "real world" experience they gain as well as the understanding of how their discipline is applied in practice:

> "*I felt that this was one of the few times that I have used my chemical knowledge in a very practical sense*"

> "*I found this assignment of great benefit as I could relate theory to practice and fully understand* it."

They also appreciated the opportunity to work for the benefit of a community partner and recognised that they had developed important transferable skills (teamwork, communication, information literacy, problem-solving):

> "*It helped me develop confidence when speaking to people I don't know*"

Their engagement was obvious throughout the projects and their feedback reinforced this:

> "*I liked the teaching experience and would like to take part in another CBL project again*."

In addition, many students expressed that they began to identify themselves as developing professional scientists and to have a clearer idea of what that involved:

> "*Seeing the many & varied uses of chemistry really opened my eyes*."
> "*I learned how to deal with potential work colleagues and bosses.*"

A comprehensive qualitative investigation of the EPICS engineering community-based learning programme at Purdue University by Thompson *et al.* has arrived at similar conclusions and has shown that those students gained a more accurate idea of what engineers really do as well as a broader view of engineering.[15] In addition, research data from the United States is demonstrating a link between student retention and their involvement in community-based learning projects and there appears to be evidence of a related improved rate of success in finding employment on graduating.

Responses to some of the questions from the student evaluation forms used for community-based learning projects are summarised in Table 3 below.

Was the CBL assignment a suitable method for assessing the associated module learning outcomes?	100% replied yes
Was sufficient information provided to allow the assignment to be completed effectively?	100% replied yes
Which do you think would provide a better learning experience, the CBL assignment or a hypothetical case study?	96% replied yes and 4% replied both case study and CBL assignment (felt case study would be good preparation)
Would you recommend that a similar type of CBL assignment be used on this module next year?	96% replied yes and 4% replied no (felt it was too much work)
Would you recommend that the School try to expand the extent to which CBL assignments are used?	100% replied yes (1 suggestion to have 1 CBL activity per year)
Do you think the community partner(s) benefited from the work you did?	100% replied yes

Table 3: Responses from student evaluation forms on community-based learning projects.

5. Integration of eLearning

The final initiative to be discussed is online learning. It has been implemented wherever it has been judged to provide a means to enhance the face-to-face teaching already in place. Use of a Virtual Learning Environment to scaffold learning for first years has already been described in Section 1. In addition, online discussion boards have been very effective as a means of communication and collaboration, both among themselves and with their academic facilitator, for groups working on project-based or community-based assignments. Wikis are used in some context-based group assignments (e.g. to prepare a fully-referenced Molecules That Matter webpage on a given compound) as the contribution from each learner can be tracked over time with the “page history” facility and the lecturer can post comments on the work as it is in progress instead of only doing so for the final product. Use of open access online learning resources such as ChemTube 3D is incorporated into lectures and labs where appropriate.

Recently, Dr Michael Seery has prepared a range of screen capture videos using Camtasia™ software to help students to learn how to use particular software packages. He has also led a project to develop interactive pre-lab and pre-lecture resources incorporating video clips using Articulate™ software.

Evaluation of the Effects of Initiatives on Motivation and Engagement

To date, the evaluations presented of the teaching and learning strategies that have been implemented (learning support measures for first year students, context-based and project-based laboratory practicals, community-based learning projects and integration of eLearning) have been performed by means of a range of methods. Questionnaires, postings on discussion boards, student reflective assignments, staff feedback (often informal, sometimes by questionnaire), student attendance and student grades have all been used as a basis for the conclusions drawn in relation to student motivation and engagement. There are some problems with this approach however. One is that it is important to recognise that motivation is both internal and external and thus some aspects are beyond our control. There is also the concern that students may, in some cases, just tell us what they think we want to hear. In addition, in some instances, it is difficult to be sure that the correct conclusion has been drawn from the data (e.g. is it valid to assume that good student grades and attendance are indicators of motivation and engagement?).

The next stage in the process is to perform some qualitative research in this area. This will be achieved by carrying out semi-structured interviews with students and staff and this work is about to begin.

Conclusions

The initiatives introduced have been designed with the intention of motivating and engaging learners during their study of chemistry at Dublin Institute of Technology. They are based on the incorporation of active learning and consideration of developments in education research and best practice. Assessments have been designed so that they align with the specified learning outcomes and e-learning methods have been incorporated where they are judged to provide “added value”. The evaluations performed to date indicate that, in the majority of cases, student motivation and engagement has been improved. In particular, the beneficial effect of community-based learning projects has been found to be very significant.

However, it is expected that the planned qualitative phase of evaluations will provide a richer source of data and will be very useful in informing further developments and improvements.

Acknowledgements

Collegiality has been an important factor in progressing this work and discussion and collaboration with colleagues and peers, particularly those in the DIT Chemical Education Research Team,[4] has proven invaluable.

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Note: The presentation given at the 2010 Variety in Chemistry Education conference on which this article is based can be accessed at: http://www.heacademy.ac.uk/assets/ps/documents/events/2010/variety/mcdonnell.pdf

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Wanted:

Old photos of school laboratories in action for a series on "The way we were". Please send a scanned image indicating the date and location to the Editor.

2010 LC Results

Peter E. Childs

We have been publishing an analysis of the LC science results and CAO points for science-related courses since 2001. Issue #86 looked at the LC results and CAO points for 2008; issue #89 looked at 2009 and gave the figures from 2006 to 2009. Each year a 3 year overview is given. The examination statistics are available at the Department of Education and Science website at: www.examinations.ie and were published in the Irish newspapers on 18/8/10, the day the LC results were released.

In 2010 54,481 students took the Leaving Certificate (LC) (this is the sum of LC (Established) and LCVP), up from 54,196 in 2009, and a further 3,358 took the Leaving Certificate Applied (LCA), making a total of 57,839. Thus the number doing the LC went up by 2,052 (3.9%) from 2008 to 2009 and by only 285 (0.52%) from 2009 to 2010. The numbers passing through the school system are expected to continue rising for several years and you can find growth predictions on the website of the Department of Education and Skills. We must take account of the changing examination cohort if we are to make sense of an increase or decrease in numbers doing a subject – this year, for example, the actual number of students doing Chemistry went up – but unless they went up by at more than 0.52% there is actually no real increase in popularity of Chemistry. (See below to find out what actually happened to the popularity of science subjects in 2010 and which were the winners and losers). The same is true for the UK A-levels where number of entries rather than number of students is usually published and this makes it impossible to see how popular a subject is compared to the size of the cohort and whether enrolment is going up or not. The raw numbers alone are not enough.

Comments on the 2010 results

Table 1 shows that all the sciences except Physics and Physics and Chemistry gained numbers and % share and Agricultural Science and Biology made the largest % gains. Over the period 2002-2010 all the sciences gained numbers except Physics and Physics & Chemistry, which have shown a steady decline. Biology continues to be the dominant LC science subject (taken by 53.7% of the cohort) and the only science subject in the top 10 (Table 7), having retained 4th. place this year. The LC cohort increased this year by 3.9%, and Biology, Chemistry and Ag. Science all gained in market share (see Tables 2 & 8). The LC cohort declined from 2002 to 2007 and since 2008 has been increasing (Table 8). The LC cohort in 2010 (2009) went up by only 285 (2,052) or 0.52% (3.9%) from 2009 and this shows continuing increase, as both increased birth rates in Ireland and immigration have increased the school population. This means in 2010 that we have more students (even more if you add in others returning to or entering education) chasing the same number of 3rd. level places. The result is seen is an overall increase in CAO points for many courses (see below, p. 27.)

Since 2002 Biology, Chemistry and Agricultural Science have all gained significantly, especially Agricultural Science (see Table 1). Physics and Physics with Chemistry have both decreased. Chemistry still has the highest % doing the Higher Level course of the science subjects (Table 2). Chemistry also shows the best gender balance (slight excess of girls), whereas Biology has more girls than boys doing it, and Physics more boys than girls. Physics is clearly in decline and this year's figures suggest that Agricultural Science may well become the third most popular science in a few years time. **There is clearly a swing towards the life sciences.** Physics & Chemistry has been on its last legs for some years and continues to decline - it is definitely a dead man walking, and it is a great pity that the new and innovative replacement, which was drawn up several years ago, has never been implemented. If the course is not going to be revised it should be dropped. It must be one of the oldest/longest-lasting science syllabi in the world by now!

Table 1 Changes in numbers doing LC Science subjects 2009-2010 (gains in bold)

Subject	Δ2009-2010	Δ% 2009-10	Δ2008-2009	Δ2002-2010 (Δ %)
Biology	**+1,089**	**+3.9**	**+1,553**	**+7,185 (+32.6)**
Chemistry	**+145**	**+2.0**	**+289**	**+1,051 (+16.2)**
Physics	-178	-2.8	-190	-1,906 (-22.0)
Phys+ Chem.	-84	-16.2	-79	-450 (-55.1)
Ag. Science	**+515**	**+9.8**	**+534**	**+2,381 (+100.2)**

From these figures in Table 1 it can be seen that Biology, Chemistry and Agricultural Science are growing in numbers and market share, whereas Physics and Physics & Chemistry are both declining. Biology is still far and away the most popular science subject, trailed considerably by Chemistry and Physics: nearly four times as many students take Biology as take Chemistry. It is clear that the Physics & Chemistry syllabus is dying on its feet, whereas Agricultural Science is growing steadily (+100.2% since 2002) and at this rate will overtake Physics in a few years. Sadly the new syllabus in Physics & Chemistry is still gathering dust on a shelf in the NCCA – it was radical and innovative syllabus and it deserved an airing – it would have provided a popular alternative to the full Physics and Chemistry syllabi. All the sciences are quite elitist with Chemistry and Physics & Chemistry heading the poll with 83.4/83.5% respectively doing the HL course.

Table 2 LC Science - % doing Higher Level and Ordinary Level 2010

	2010	HL 2010 (%)	OL 2010 (%)	%LC cohort 2010	%LC cohort 2009
Biology	29,249	20,971 (71.7%)	8,278 (28.3%)	53.7	51.8
Chemistry	7,548	6,298 (83.4%)	1,250 (16.6%)	13.85	13.7
Physics	6,745	4,877 (72.3%)	1,868 (27.7%)	12.4	12.8
Phys.+Chem.	425	355 (83.5%)	70 (16.5%)	0.78	0.96
Ag. Science	5,787	4,675 (80.8%)	1,112 (19.8%)	10.6	9.7

Figure 1 Change in % doing Biology■, Physics▲ and Chemistry♦ 1999-2010

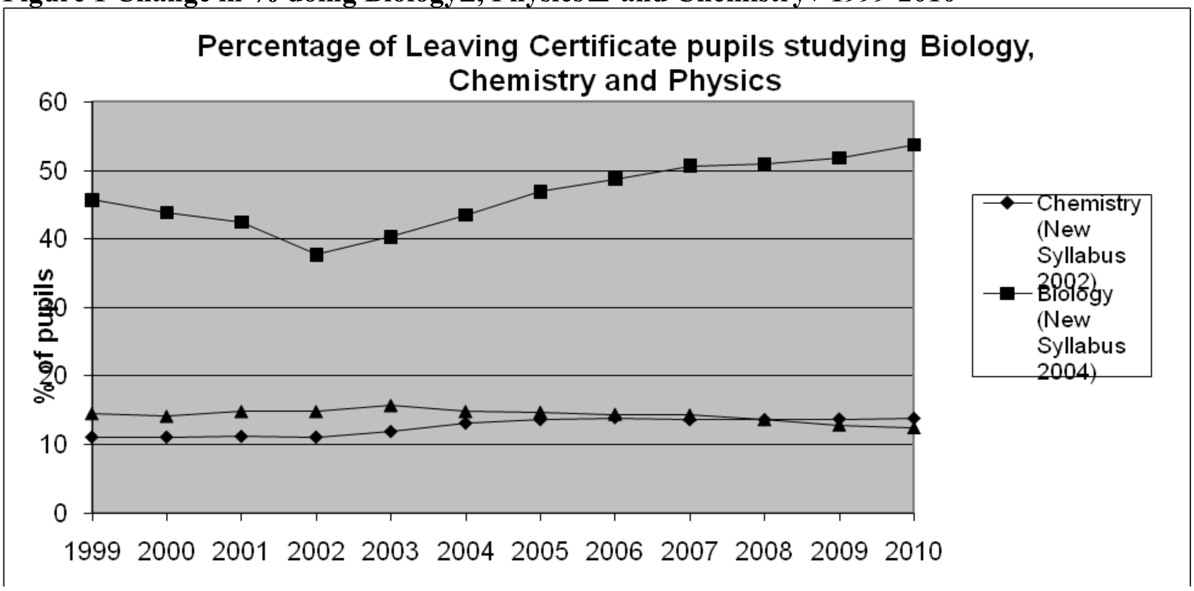

Table 3 % of different grade bands 2006-2010

a)Chemistry **Higher level** Ordinary level

Year	**2010**	**2009**	**2008**	**2007**	**2006**	2010	2009	2008	2007	2006
%A	**20.8**	**21.6**	**23.5**	**21.0**	**21.8**	7.6	9.2	11.7	8.0	7.0
%A+B	**50.1**	**52.9**	**54.6**	**54.1**	**50.8**	29.8	34.6	42.2	31.8	32.3
%A+B+C	**75.3**	**77.5**	**78.7**	**79.0**	**75.6**	54.9	63.1	75.0	58.5	59.7
%E,F,NG	**6.1**	**7.0**	**5.8**	**5.5**	**7.4**	18.5	15.3	13.9	16.8	15.5

b) Biology **Higher level** Ordinary level

Year	**2010**	**2009**	**2008**	**2007**	**2006**	2010	2009	2008	2007	2006
%A	**17.4**	**16.0**	**16.6**	**19.5**	**16.5**	3.1	3.6	4.8	2.7	3.9
%A+B	**44.9**	**43.0**	**43.9**	**46.7**	**43.7**	29.6	26.3	29.7	24.5	30.5
%A+B+C	**71.6**	**69.9**	**71.5**	**71.7**	**71.6**	62.7	59.1	63.2	57.8	64.9
%E,F,NG	**9.2**	**8.8**	**7.9**	**7.9**	**7.2**	14.1	15.3	11.1	15.0	13.2

c) Physics **Higher level** Ordinary level

Year	**2010**	**2009**	**2008**	**2007**	**2006**	2010	2009	2008	2007	2006
%A	**20.8**	**20.3**	**19.9**	**21.4**	**19.5**	17.4	17.0	15.5	13.5	13.8
%A+B	**49.6**	**49.6**	**46.4**	**49.7**	**46.8**	49.0	49.7	47.3	43.8	45.7
%A+B+C	**73.3**	**72.9**	**70.8**	**75.8**	**70.5**	72.8	74.3	73.8	72.9	72.8
%E,F,NG	**7.0**	**7.8**	**8.6**	**7.5**	**7.2**	11.6	10.0	8.7	9.7	9.0

In 2010 for both Chemistry and Physics 20.8% of HL students got A1 or A2 compared to 17.4% for Biology. This reflects the wider intake into Biology and probably that Chemistry and Physics tend to attract higher ability students. These results are fairly consistent over 5 years as can be seen above. At OL the differences are more marked – Physics students get 17.4% As at OL, whereas Chemistry students get 7.6% and Biology students 3.1%. It should also be noted that Biology has the highest % of failing grades at HL but Chemistry has the highest % of failing grades at OL. There is no marked change in the grading over this period for any of the three main science subjects.

In Table 3 you can compare the grades obtained in each subject at Higher and Ordinary level. Four bands are shown: %As, %A+Bs, %A+B+Cs and %E+F+NG (fails). Chemistry and Physics are more selective subjects i.e. they are done by smaller numbers and a higher % take the Higher Level papers, indicating that these are taken by better students. We would thus expect a higher % of good grades and less % of fails if the student populations doing Chemistry and Physics are more selective. This is what we observe. From 2006-10 the average % getting As in HL papers in Chemistry was 21.7% and 20.4% in Physics, compared to 17.2% in Biology. This does not mean that Biology is harder than Chemistry or Physics: it means that a larger number of students take Biology and have a greater ability spread, compared to Chemistry and Physics. This is also consistent with the average % of fails in HL Chemistry of 6.4% 2006-10, compared to 7.6% in HL Physics and 8.2% in HL Biology.

At Ordinary Level we would expect to see smaller % of good grades, as weaker students opt for the ordinary level papers - often at the last minute, and a greater % of fails. We would also expect more % fails in Biology than Physics and Chemistry because of the greater numbers and greater ability spread of students choosing Biology. The average % getting As in ordinary level Chemistry was 8.7% from 2006-10, with 15.4% getting As in Physics and 3.6% in Biology. The anomaly here is the high % of As in Physics. When we look at the % fails in the ordinary level papers from 2006-10, 16.0% fail Chemistry, 13.7% fail Biology and 9.8% fail Physics.

We would in fact expect an even higher % of good grades in both Chemistry and Physics given the highly selective populations doing these subjects. An important study by Kellaghan and Millar (2003) compared performance in different LC subjects by comparing a student's performance in pairs of subjects. A preliminary report on the study was given in the Report of the Task Force on the Physical Sciences (2002). This found that a student on average got lower grades in Chemistry and Physics compared to other subjects they took, indicating that it is actually more difficult to get high grades in these subjects. The difference was between half and 1 ½ grades, which is a significant difference. This important study should be repeated at intervals to check on the comparability of marks across different subjects. It agrees with the anecdotal perception of students, parents and teachers that it is harder to get good grades in Chemistry and Physics, notwithstanding the already high % of As and Bs in these subjects. If this effect was allowed for, a even greater % of students would get As in Chemistry and Physics than they do at present and this might make the subjects more attractive.

Table 4 Gender breakdown of grades 2010

	%As overall	**%As females**	**% As males**
Chemistry	20.8 (HL) 7.6 (OL)	**20.9 (HL) 11.3 (OL)**	20.4 (HL) 3.7 (OL)
Biology	17.4 (HL) 3.1 (OL)	**17.5 (HL)** 2.9 (OL)	17.2 (HL) 3.3 (OL)
Physics	20.8 (HL) 17.4 (OL)	**23.6 (HL) 23.0 (OL)**	19.7 (HL) 16.3 (OL)

Table 4 shows the gender breakdown of the HL and OL results for A grades. In nearly all cases females outperform males (shown in bold above), even in Physics which is the most male-dominated science subject and this is most marked in Chemistry OL. The trend for females to outperform males in state examinations has become more apparent year on year. We cannot say from these data whether this difference is due to intrinsic ability or to better study methods and harder work.

Table 5 shows the overall gender breakdown of the five science subjects i.e. HL and OL students are combined in these figures.

Table 5 The overall gender balance in the LC Science subjects 2010

Subject	**No. females (%)**	**No. males (%)**	**Ratio F:M**
Biology	18,612 (63.6%)	10,637 (36.4%)	1.75
Chemistry	4,248 (56.3%)	3,300 (43.7%)	1.29
Physics	1,689 (25.0%)	5,056 (75.0%)	0.33
Physics & Chemistry	161 (37.9%)	264 (62.1%)	0.61
Agricultural Science	2,055 (35.5%)	3,732 (64.5%)	0.55

Biology is clearly dominated by females and Physics is dominated by males. Chemistry shows the closest gender balance, and the proportion of females continues to increase. This marked disparity between Biology and the Physical Sciences is more marked in Ireland than in most other countries.

In Table 6 the grades for all five science subjects are shown from 2007 to 2010, at both Higher and Ordinary level.

Table 5 2007-2010 LC Science Results at HL and OL (Source: DES Statistics) (Current year in bold)

Chemistry	No.	A1	A2	B1	B2	B3	C1	C2	C3	D1	D2	D3	E	F	NG
HL 2010	**6,298**	**9.7**	**11.1**	**9.7**	**10.2**	**9.4**	**8.5**	**8.6**	**8.1**	**5.4**	**5.0**	**6.3**	**5.3**	**2.2**	**0.6**
HL 2009	6,037	12.3	9.3	10.4	11.0	9.9	8.5	8.1	8.0	4.5	4.9	6.2	4.7	1.8	0.5
HL 2008	5,904	12.9	10.6	10.7	10.4	10.0	8.8	8.0	7.3	5.4	4.6	5.5	4.2	1.3	0.3
HL 2007	5,729	9.7	11.1	10.7	11.7	10.8	9.1	8.3	7.4	5.4	4.9	5.2	3.7	1.6	0.3
OL 2010	**1,250**	**2.2**	**5.4**	**4.9**	**8.6**	**8.7**	**9.1**	**9.1**	**8.1**	**7.9**	**7.7**	**9.8**	**10.1**	**6.8**	**1.6**
OL 2009	1,366	3.0	6.2	5.9	8.6	10.9	10.8	8.6	9.1	5.3	6.8	9.4	8.7	5.6	1.0
OL 2008	1,210	5.3	6.4	9.2	9.7	11.6	9.8	7.9	7.9	6.4	4.8	7.3	7.8	4.9	1.2
OL 2007	1,197	3.3	4.7	5.0	8.3	10.5	9.0	9.0	8.7	8.0	5.7	11.0	10.4	5.3	1.1
Biology	**No.**	**A1**	**A2**	**B1**	**B2**	**B3**	**C 1**	**C2**	**C3**	**D1**	**D2**	**D3**	**E**	**F**	**G**
HL 2010	**20,971**	**8.9**	**8.5**	**8.4**	**9.1**	**10.0**	**8.5**	**8.9**	**8.3**	**6.9**	**6.3**	**7.0**	**6.9**	**2.0**	**0.3**
HL 2009	20,101	7.7	8.5	8.1	90	9.9	8.9	9.1	8.9	7.2	6.7	7.2	7.0	1.6	0.2
HL 2008	18,323	8.5	8.1	8.1	9.3	9.9	9.2	9.3	9.1	7.0	6.4	7.2	6.2	1.6	0.1
HL 2007	17,521	10.7	8.8	8.7	8.9	9.6	8.4	8.2	8.4	7.2	6.4	6.7	6.1	1.6	0.2
OL 2010	**8,278**	**0.7**	**2.4**	**5.3**	**9.3**	**11.9**	**11.5**	**11.5**	**10.1**	**8.1**	**6.7**	**8.4**	**8.7**	**4.5**	**0.9**
OL 2009	7,999	1.0	2.6	5.2	7.5	10.0	11.0	11.3	10.5	9.6	7.8	8.4	9.9	5.0	0.4
OL 2008	8,284	1.5	3.3	5.7	8.2	11.0	10.9	11.4	11.2	9.6	7.4	8.7	8.1	2.8	0.2
OL 2007	8,270	0.6	2.1	4.7	7.1	10.0	10.7	10.7	11.9	10.3	8.0	8.8	10.2	4.4	0.4
Physics	**No.**	**A1**	**A2**	**B1**	**B2**	**B3**	**C1**	**C2**	**C3**	**D1**	**D2**	**D3**	**E**	**F**	**NG**
HL 2010	**4,877**	**8.8**	**12.0**	**8.4**	**10.8**	**9.6**	**9.2**	**9.4**	**5.1**	**8.8**	**6.0**	**5.0**	**5.2**	**1.4**	**0.4**
HL 2009	4,693	10.6	9.7	10.2	10.2	8.9	8.6	8.6	6.1	7.2	5.8	6.3	5.1	2.4	0.3
HL 2008	4,929	12.7	7.2	10.5	8.0	8.0	7.7	8.7	8.0	6.4	5.8	8.4	6.2	2.0	0.4
HL 2007	5,223	12.4	9.0	6.3	9.0	9.4	9.0	8.5	8.6	7.2	5.6	7.5	5.4	1.8	0.3
OL 2010	**1,868**	**8.0**	**9.4**	**9.0**	**9.8**	**12.8**	**7.5**	**7.2**	**9.1**	**3.9**	**4.4**	**7.3**	**5.8**	**4.2**	**1.6**
OL 2009	2,230	5.7	11.3	9.2	10.0	13.5	8.2	8.2	8.2	5.4	4.5	5.8	5.7	3.3	1.0
OL 2008	2,183	6.6	8.9	9.2	11.1	11.5	8.3	8.9	9.3	4.4	5.7	7.5	6.0	2.1	0.6
OL 2007	2,028	3.5	10.0	6.0	8.6	15.7	9.0	9.2	10.9	4.3	6.2	6.8	5.2	3.4	1.1
Phys+Chem	**No.**	**A1**	**A2**	**B1**	**B2**	**B3**	**C 1**	**C2**	**C3**	**D1**	**D2**	**D3**	**E**	**F**	**G**
HL 2010	**355**	**8.2**	**11.3**	**7.9**	**12.1**	**6.2**	**10.1**	**4.5**	**7.0**	**4.8**	**6.2**	**6.2**	**8.5**	**3.7**	**3.4**
HL 2009	408	7.8	9.3	7.8	10.3	8.6	7.6	9.1	9.3	6.1	6.4	7.1	5.9	3.7	1.0
HL 2008	454	16.7	9.0	7.7	10.1	8.8	6.6	4.6	9.3	4.6	2.4	7.0	7.3	4.4	1.3
HL 2007	392	10.5	12.5	8.7	8.4	8.4	8.9	8.4	8.4	5.4	5.4	5.4	6.1	3.1	0.5
OL 2010	**70**	**1.4**	**2.9**	**2.9**	**2.9**	**5.7**	**2.9**	**5.7**	**14.3**	**7.1**	**7.1**	**18.6**	**12.9**	**10.0**	**5.7**
OL 2009	111	1.8	3.6	0.0	2.7	9.9	1.8	8.1	16.2	9.0	9.9	10.8	11.7	10.8	3.6
OL 2008	144	2.1	2.1	2.8	6.9	6.3	10.4	8.3	9.7	9.7	7.6	9.7	11.1	9.0	4.2
OL 2007	146	1.4	3.4	2.7	9.6	8.2	8.2	8.9	8.9	5.5	11.6	8.2	8.9	11.0	3.4
Ag. Science	**No.**	**A1**	**A2**	**B1**	**B2**	**B3**	**C1**	**C2**	**C3**	**D1**	**D2**	**D3**	**E**	**F**	**NG**
HL 2010	**4,675**	**3.8**	**6.1**	**7.7**	**9.2**	**9.9**	**10.5**	**10,8**	**10.2**	**9.3**	**7.5**	**7.7**	**6.3**	**1.1**	**0.1**
HL 2009	4,164	5.7	6.9	8.0	8.7	9.4	9.8	9.3	10.4	9.3	7.0	7.4	6.6	1.4	0.0
HL 2008	3,712	7.2	6.3	8.0	8.4	8.8	10.0	10.1	9.4	8.4	7.0	8.2	6.7	1.3	0.1
HL 2007	3,261	3.8	4.9	7.1	7.9	9.7	11.5	11.3	11.3	9.9	8.0	7.7	5.8	1.0	0.1
OL 2010	**1,112**	**0.1**	**0.3**	**1.8**	**5.2**	**7.3**	**11.0**	**11.9**	**13.5**	**12.8**	**12.0**	**11.0**	**9.9**	**3.2**	**0.2**
OL 2009	1,108	0.0	0.4	1.2	3.0	5.1	7.3	11.9	13.4	14.3	10.6	13.4	13.3	5.8	0.5
OL 2008	1,025	0.1	0.7	1.9	2.9	7.9	9.3	13.6	13.0	14.3	10.7	12.3	10.8	2.4	0.1
OL 2007	1,006	0.1	0.5	1.1	2.5	5.1	7.8	11.7	11.6	13.0	11.9	13.1	14.7	6.1	0.8

(LC Grading at Higher Level: A1 90-100%; A2 85-89%; B1 80-84%; B2 75-79%; B3 70-74%; C1 65-69%; C2 60-64%; C3 55-59%; D1 50-54%; D2 45-49%; D3 40-44%; E 25-39%; F 10-24%; NG 0-9%)

Table 7 shows the top 10 LC subjects from 2007 to 2010. Maths retains its first place and nearly everyone who stays on a school until age 17/18 does maths and does an examination in it. Biology is in 4th place since 2009 (previously 5th) and the most popular Science subject. Five subjects are taken by >50% of the LC cohort.

Table 7 Top 10 LC subjects from 2010 to 2007 (HL+OL)

Subject	**2007 Total (HL+OL)**	**2008 Total (HL+OL)**	**2009 Total (HL+OL)**	**2010 Total (HL+OL)**	**% LC cohort 2010**
Maths (+FL)	49,043	50,116	51,902	**52,290**	**95.9**
English	48,455	49,382	51,032	**51,499**	**94.5**
Irish (+FL)	44,018	44,660	45,636	**41,043**	**75.3**
Biology	25,791	26,607	28,160	**29,249**	**53.7**
French	27,805	27,698	27,675	**27,574**	**50.6**
Geography	24,218	24,360	25,061	**26,175**	**48.0**
Business	18,957	18,733	18,425	**18,790**	**34.5**
Home Econs.	12,250	12,497	12,936	**12,535**	**23.0**
History	11,363	11,850	11,990	**11,910**	**21.9**
Art	10,133	10,283	10,693	**10,786**	**19.8**

Table 8 shows the change in the LC cohort (Established + Applied) from 2002 to 2010, together with the % of the cohort taking Biology, Chemistry or Physics (these are shown graphically in Figure 1 above). Biology is clearly in the ascendant and numbers and % share have climbed steadily since the new syllabus was introduced and examined first in 2004. The new Physics and Chemistry syllabi were first examined in 2002 and since then Physics has been on a slow decline and Chemistry on a slow increase, so that Chemistry overtook Physics in 2009.

Table 8 Changes in the LC cohort and science subjects 2002-2010

	LC Cohort	**Biology Total**	**%**	**Chemistry Total**	**%**	**Physics Total**	**%**
2002	58,489	22,064	37.7	6,497	11.1	8,651	14.8
2003	56,229	22,669	40.3	6,698	11.9	8,806	15.7
2004	55,183	24,027	43.5	7,229	13.1	8,152	14.8
2005	54,069	25,362	46.9	7,366	13.6	7,944	14.7
2006	50,995	24,885	48.8	7,071	13.9	7,335	14.4
2007	50,870	25,792	50.7	6,926	13.6	7,251	14.3
2008	52,144	26,607	51.0	7,114	13.6	7,112	13.6
2009	54,196	28,160	51.8	7,403	13.7	6,923	12.8
2010	**54,481**	**29,249**	**53.7**	**7,548**	**13.85**	**6,745**	**12.4**

***New Biology syllabus examined from 2004 onwards; new Physics and Chemistry syllabi examined from 2002.**

Table 9 shows the change in size of the LC cohort from 2005 to 2010. In 2010 (2009) there were 3,737 (4,361) external candidates and 2,823 (2,211) repeat candidates. After a minimum number in 2007 numbers doing the LC have now increased above 2005 levels and are due to continue increasing in the future.

Table 9 Change in LC numbers 2005-2010

Year	LC Established	LCVP	Total LC (Est) + LCVP	LCAP	Total
2005	39,792	14,281	54,073	3,318	57,391
2006	36,932	14,023	50,955	3,155	54,110
2007	36,790	14,080	50,870	3,056	53,926
2008	37,639	14,505	52,144	3,445	55,589
2009	39,112	15,084	54,196	3,259	57,455
2010	**38,885**	**15,596**	**54,481**	**3,358**	**57,839**

The Maths problem

Every year there is a big discussion in the papers about Maths - the small number doing the HL paper and the high % of fails at HL and OL. The results in Maths are of great interest to science teachers, and 3rd level science lecturers, because Maths is the language and underpinning foundation of science, particularly the physical sciences. It is also vital for engineering subjects at school and 3rd. level.

Ireland's performance in Maths is not as bad as some of the critics make out. I think we should be optimistic because so many people continue to study Maths until the end of school – Ireland has one of the highest enrolments in Maths to age 17/18 in the world (see Table 10). Ireland should actually be in the top group.

Table 10 % of upper secondary students taking Maths in various countries (Nuffield Foundation, www.nuffieldfoundation.org)

Countries	% Upper secondary students taking maths
Czech Rep., Estonia, Finland, Japan, S. Korea, Russia, Sweden, Taiwan	95-100
Australia, Canada, France, Germany, Hungary, **Ireland,** Netherlands, New Zealand, Singapore, US	50-95
Scotland, Hong Kong, Spain	20-50
England, Wales, N. Ireland	< 20

This **should** mean that almost everyone leaving school and entering 3rd level is mathematically literate and numerate to some extent. However, as all teachers know well, studying something is no guarantee that you have understood or mastered it.

The results for Maths from 2010 to 2008 are shown in Table 11 below. Table 7 reminds us that Maths is the most popular LC subject (95.8%) even though it is not formally compulsory. This means that virtually everyone who completes the senior cycle in Ireland has done a course in Mathematics. In the UK, for example, the majority of students drop Maths after the junior cycle and only a minority carry on with it to A-level. This should mean that Ireland has one of the most mathematically literate populations in Europe, if not in the world. The % who did the Higher Level paper was 15.4 % in 2010, 15.5% in 2009 and 16.3% in 2008. The number and % doing HL Maths is greater than that doing HL Chemistry or Physics, although we might well expect them to be the same students (see Table 12). Considering that almost the whole LC cohort does Maths, the % failures at HL (3.7%) and OL (9.8%) are quite small. Doing a course does not necessarily mean that one will pass it and the wider the ability range of students taking a subject, the greater the % of fails we would expect. Maths is directly comparable to the science subjects as Maths is taken by almost everyone and the sciences are self-selected: Physics and Chemistry are done by the more academic students, as reflected by the high % of HL students. I am not sure if we should realistically expect a much higher % of students to take HL Maths than do at present.

Table 11 below shows the Maths grades from 2010-2008 at HL, O and FL (Foundation Level).The vast majority of students take Maths at OL (72.5%).

Table 11 LC Maths results 2010-2008 at HL, OL and FL (2008-2010)

Maths	No.	A1	A2	B1	B2	B3	C1	C2	C3	D1	D2	D3	E	F	NG
HL2010	**8,390**	**7.3**	**7.0**	**8.3**	**10.1**	**10.6**	**12.5**	**11.6**	**10.3**	**8.1**	**5.5**	**5.0**	**2.9**	**0.6**	**0.2**
HL 2009	8,420	6.7	8.1	9.4	11.7	12.2	11.8	11.8	8.9	7.2	5.1	3.8	2.6	0.6	0.1
HL 2008	8,510	7.7	6.9	8.6	10.0	12.1	11.2	11.7	10.0	6.8	5.4	5.3	3.5	0.7	0.2
OL 2010	37,903	4.5	6.8	8.5	9.6	10.0	9.9	9.9	9.5	8.1	6.8	6.8	6.8	2.6	0.4
OL 2009	37,272	5.7	7.0	8.3	9.2	9.7	9.5	9.3	8.6	7.9	7.0	7.3	7.6	2.5	0.3
OL 2008	35,808	4.9	7.6	9.1	9.7	9.4	9.6	8.8	8.2	7.2	6.4	7.0	8.0	3.7	0.5
FL 2010	5,997	3.8	6.5	10.9	13.1	14.1	13.0	10.7	8.0	6.3	4.9	4.0	3.4	1,2	0.2
FL 2009	6,210	4.2	6.7	10.0	12.8	13.2	11.9	10.8	8.2	7.1	5.1	4.9	3.7	12	0.2
FL 2008	5,803	3.9	5.9	8.8	12.4	13.4	12.5	10.4	9.3	6.8	5.8	5.0	3.7	1.8	0.2

Table 12 Comparison of HL Maths, Chemistry, Physics and Biology (2010)

	Maths	**Chemistry**	**Physics**	**Biology**
Number doing HL (% LC cohort)	8,390 (15.4)	6,298 (11.6)	4,877 (8.95)	20,971 (38.5)
% doing HL vs OL	16.0	83.4	72.3	71.7
% As	14.3	20.8	20.8	17.4
%A+Bs	43.3	50.1	49.6	44.9
% fails	3.7	6.1	7.0	9.2

More students take Maths than any other subject but it has one of the smallest % doing the HL paper. The disparity with the three main science subjects is clear from the data above. Maths at HL also performs less well than the three science subjects in the % getting As and A+Bs.

An important question we should ask is, **"Is every pupil in senior cycle capable of taking HL Maths?"** A higher % take HL Maths for the Junior Certificate than at the Leaving Certificate, though not as high as for JC Science, but this is not as demanding a course as LC Maths, just as JC Science is not as demanding as the LC science subjects. In order to do HL Maths (and HL Physics and Chemistry as well) a pupil needs to be able to think abstractly, handle concepts, understand logic etc. This means they have to be able to think at a fairly high level, what educational psychologists call the 'formal operational level'. The evidence of large scale studies of second level students in the UK (e.g. Shayer and Adey, 1981), as well as evidence collected in Ireland (Childs and Sheehan, 2009) indicates that only a small percentage of students (<20%) at ages 16/17/18 is capable of the abstract, logical, conceptual thought needed by Mathematics and the Physical Sciences. This still true for first year college students, although the % capable of formal thought is higher (30-40%),especially for self-selecting courses which require a high level of Mathematics and the Physical Sciences. So perhaps the major reason why more pupils don't take HL Maths is that they are not able to cope with the intellectual demands of the course, given their own state of development. If they did it, they would almost certainly do badly and increase the number of fails.

The same applies to those who choose to study Physics and Chemistry, mostly at HL – they may represent the % of the school population capable of doing these abstract, conceptual and mathematical subjects. By the same argument, because not all pupils are capable of the type of thinking required in Maths and the Physical Sciences, we would expect to find them either avoiding the subject (for Chemistry and Physics) or opting for the OL course (Mathematics). We would also expect to find some pupils who cannot cope with the subjects at all and even though they take them, they fail. If we are taking almost the whole age cohort (at JC) and >80% at LC, we would expect a significant proportion of students to be of low ability (half are less than average), who cannot cope with the demands of even OL material.

We can only expect everyone to pass examinations, at JC or LC level, if we lower the standards enough so that everyone gets through. The examinations and the results then become largely meaningless as we are ignoring the innate differences between pupils. The present arrangement in Maths where it is offered at 3 levels seems to be ideal: everyone has a chance to do Maths at a level that suits their own intellectual development. We should expect and require basic numeracy for everyone, but everyone cannot and will not be a mathematician. What we should be doing is making sure that all those who are capable of doing HL Maths are in fact doing it, as it is from this pool that the future scientists and engineers as well as mathematicians will come.

2010 saw the first schools taking parts of Project Maths in their papers and from Sept. 2010 Project Maths was rolled out to all schools. It is too soon to say what effect this will have on Maths enrolment or results. It is hoped that Project Maths will make the subject more interesting, more relevant and more manageable for students and that it will increase the % doing the HL course. Whether they will then be properly equipped with the mathematical skills necessary to pursue science and engineering at 3rd. level is another question. There have been significant negative comments on Project Maths from teachers and 3rd level mathematicians. This might encourage more students to attempt the HL course.

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□

CAO Points 2010 and Course Entry

Peter E. Childs

2010 saw a large increase in the number of people applying through the CAO system for 3rd level entry for level 8 (honours degrees) and level 6 (certificate)/7 (ordinary degrees) courses. Not surprisingly the entries for many courses went up and the cut-off points increased. Thus it was more difficult for students to get into courses of their choice due to the greater demand and many students were left without any offers. The level of unemployment meant that many more mature students were seeking to enter higher education and this is likely to increase further in 2011. In later years there will also be increased demand due to the higher birth rate working its way through the system. It is going to get harder not easier to get into college in future. The CAO points required for a course depends on the demand for the course and the number of places available. Thus high demand courses with few places have a high points cut-off. In 2010 science and engineering courses showed an increase in demand, whereas pharmacy showed a decrease.

Table 1 Level 8 Courses 2010

Area	**Points range**	**%Change 2009-2010**
Liberal arts	350-380	}+10%
Social science/Comm.	375-395	}
Business	400-450	
Science	**360-430**	**+8.6%**
Primary Teaching	465-480	-4.2%
Engineering 390-440	**+6.5%**	
Law	480=520	-7%
Medicine(inc. HPAT)	720-730	+11%
Nursing	400-450	+6%
Architecture	400-500	-10%
Agriculture/Food	400-420	-4.7%
Pharmacy	530-540	-26.3%

There are now a wide range of science-related courses available and the list below in Table 4 focuses on those with appreciable chemistry content. Science courses are offered in several places, UCD and TCD having the largest numbers, and these are usually common entry or undenominated courses i.e. students take several subjects in first and/or second year and can delay choosing their final degree subjects. Denominated courses are in a specific area of science and a student entering those courses will graduate with a degree in that area, even though the first and/or second year are broadly based. In the table below we give the institution (see abbreviations at the end), the course title and the cut-off points and median points in 2010. The cut-off points indicate the lowest points score needed to get a place. An * indicates that the final places were allocated by random selection. The median indicates the score half way between the cut-off and the highest score – it is not the mean score of students on the course. If the cut-off and the median are close together it means that the spread of points amongst students is not very high.
Just a reminder of the way points are scored for the CAO applications:

Table 2 CAO points scores for LC grades

LEAVING CERTIFICATE POINTS CALCULATOR

GRADE	HIGH	ORD	FOUND MATHS
A1	100	60	20
A2	90	50	15
B1	85	45	10
B3	80	40	5
C1	70	30	
C2	65	25	
C3	60	20	
D1	55	15	
D2	50	10	
D3	45	5	

LEAVING CERTIFICATE VOCATIONAL PROGRAMME

Distinction	70
Merit	50
Pass	30

The table below shows the % of students getting points in the specified ranges in 2010. It can be seen from this that the mean points score is between 300 and 325. Thus any course whose cut-off drops below 310 or so is recruiting some students from the lower half of the cohort. There is no significant change in the % of students getting high points in 2010 compared to 2009. However, over the years there has been a significant increase in the points.

Table 3 % in each CAO points range 2010 and 2009

Points range	% 2010 (cum%)	% 2009 (cum%)
600 Max	0.2 (100.0)	0.3 (100.1)
550-595	2.5 (99.8)	2.3 (99.8)
500-545	5.9(96.9)	5.9 (97.5)
450-495	9.6 (91.4)	9.5 (91.6)
400-445	12.4 (81.8)	12.0 (82.1)
350-395	13.3(69.4)	13.1 (70.1)
300-345	12.1 (56.1)	12.2 (57.0)
250-295	10.1 (44.0)	10.0 (44.8)
200-245	9.0 (33.9)	8.5 (34.8)
150-195	7.1 (24.9)	7.4 (26.3)
100-145	6.3 (17.8)	6.7 (18.9)
<100	11.5 (11.5)	12.2 (12.2)

Table 4 shows the CAO cut-off points (and medians) for Chemistry-related courses (2010) for all the institutions offering level 8 courses (honours degrees). The final cut-off points for 2009 are also shown so you can see whether there has been an increase or decrease – courses in bold have shown an increase from 2009 to 2010. Courses without any points are new courses, which either were not offered in 2009 (no points for 2009) or are new courses in 2011.

After the data in this table for each institution we look some specific subject areas e.g. Pharmacy or Forensic Science and look at the points required in different institutions. It also gives an idea of the demand/popularity of different subject areas.

Table 4 CAO cut-off points (and medians) for Chemistry-related courses (2010)
(Ones in bold increased in 2010)

College	**Course**	**2010 CAO score**		**2009**
		Cut-off	**Median**	**Cut-off**
AIT	**Toxicology**	280	345	275
	Pharm.Science			
CIT	Chem/Pharm Eng.	360	450	375
	Science (CE)	320	355	295
	Biomed. Eng. (UCC)	490	505	410
	Pharm Biotech.	320	370	300
	Herbal science	300	350	225
	Nutr. & Health Sci.	330	365	275
	Anal.Chem.+QA	235	320	285
	Env.Sci.+Sus.Tech.	330	355	
	Sus. Energy	390	415	380
	Biomed. Eng.	275	480	350
DCU	**Anal. Science**	380	405	370
	Chem.&Pharm.Sci.	380	400	370
	Env.Sci.&Health	375	400	350
	Biotechnology	380	425	360
	Biomed. Eng.	335	420	325
	Science (CE)	375	400	360
	Sport Sci.&Health	445	460	440
	Science Ed.(P+C)	415	440	400
	PE + Biology	485	500	475
DIT	For.&Env.Anal.	335	375	340
	Biomed. Science	420	445	375
	Science&Nanotech.	320	350	315
	Chem.Sci.&Med.Chem.	335	375	
	Nutri. Health&Nutr.	360	385	350
	Food Innovation	305	345	245
	Pharm.Healthcare	315	345	305
	Env. Health	330	370	325
GMIT	**App.Biol.&Biopharm.**	330	350	305
	Chem.&Pharm.Sci.	310	325	305
	Science (undenom)	330	345	300
	For. Sci.& Anal.	400	425	
IT Carlow	Biosci.+Biofor.			
	Biopharm. 295	340	300	
	Env. Science	310	360	
	Sport Science	410	420	
IT Sligo	**Env. Science**	300	325	285
	Pharm. Science270	310	265	
	For.Invest.&Anal.	340	365	350
	Med. Biotech.	295	365	255
IT Tallaght	**Pharm. Science**	310	325	260
	DNA &For. Science	350	375	
IT Tralee	**Pharm.Anal.&For.**	330	375	295
	Pharm.Anal./Env.Sci.	295	310	315
	Pharm.Anal.&Cos.Sci.			
LIT	Pharm.&For.Anal.	370	395	390
	Drug&Med.Pro.Anal.	275	310	250
NUIM	**Science**	365	395	350
	Biotechnology	360	380	355

	Pharm&Biomd.Chem.	365	405	350
	Science Ed.	465	480	370
NUIG	**Science**	345	410	325
	Biomed.Sci.	485	505	465
	Biotech.	370	400	330
	Env.Sci.	365	400	365
	Biopharm.Chem.	395	445	330
	Biomed.Eng.	405	465	425
	Env.Eng.	310	390	415
RCSI	Pharmacy	530	535	530*
TCD	**Science**	455*	495	440*
	Pharmacy	540	550	545*
	Chem.&Mol.Mod.	400	465	430
	Med.Chem.	475*	505	460
	Phys.Chem.Adv.Mats.	**410**	**460**	**445**
UCC	**Biol.&Chem.Sci.**	375	440	350
	Env.Earth Syst.Sci.	370	425	400
	Chem.Sci.	365	400	330
	Nutrit. Sci.	470	490	465
	Food Sci.	335	380	335
	Proc.&Chem.Eng.	455	500	475
	Pharmacy	540	555	545
UCD	**Science**	435	465	385
	Pharmacology	450	480	440
	Med.Chem/Chm.Biol	435	465	410
	Biomed.,Health&LS	505	525	495
	Biochem.&Mol.Biol.	430	465	430
	Food Sci.	410	435	380
UL	Pharm.&Ind.Chem.	360	410	365
	Ind.Biochem.	370	460	375
	Env. Sci.	360	395	365
	Food Sci.&Health	360	405	365
	Health&Safety	345	385	320
	Energy	400	435	435
	Sport&Ex.Sci.	425*	455	450
	PE+Teacher Ed.	495+	515	500
	Sci.Ed.(B+P/C)	455	480	460
	Sci.Ed.(P+C)	450	470	460
	Chem.&Biochem.Eng.	400	490	
	Science choice	360	410	
WIT	Pharm.Sci. 325	355	325	

Key: AIT Athlone IT, CIT Cork IT, DCU Dublin City University,DIT Dublin Institute of Technology, GMIT Galway-Mayo IT, IT Carlow, IT Sligo, IT Tallaght, IT Tralee, LIT Limerick Institute of Technology, NUIM NUI Maynooth. NUIG NUI Galway, RCSI Royal College of Surgeons of Ireland, TCD Trinity College Dublin, UCC University College Cork, UCD University College Dublin, UL University of Limerick, WIT Waterford IT (IT = Institute of Technology; NUI = National University of Ireland)

Comparison of specific subject areas

Science courses

One thing that struck me form analysing this year's courses is the rise in the number of Science courses i.e. general, common entry or undenominated science courses, where students only specialise later in the course (usually in 3rd year). Such courses have been long established in TCD, NUIG and UCD and have large intakes, but many more institutions are now offering them. There are eight courses on offer (6 at universities and 2 at ITs) and the average number of points required is 378, which is very healthy and has shown an increase in the last few years. Both TCD and UCD have a very strong intake.

CIT	Science (CE)	360
DCU	Science (CE)	375
GMIT	Science (CE)	330
NUIM	Science	365
NUIG	Science	345
TCD	Science	455*
UCD	Science	435
UL	Science	360

Science Education courses

Three institutions offer 4 year honours degrees in science education – DCU, UL and NUIM. UCC has an option within the science program to take science education. NUIM's course is the most recent one.

DCU	415
NUIM	465
UL - Biol.Sci.	455
-Phys.Sci.	450
- PE + elective	495*

The average points required are 446 (exc. PE+Elective at UL) indicating high demand for these courses. Despite the very poor job prospects for teachers good students are still choosing to train to be second level (and also primary level) teachers.

Pharmacy

Pharmacy remains the queen of the chemical sciences in Ireland in terms of points – there are 3 courses (UCC, TCD, RCSI) and the average number of points required is 537.

Chemical engineering

There are four chemical engineering courses, with a new 4 year honours degree starting in UL this year. Three courses are denominated but the course at UCD starts as Engineering and Chemical Engineering is an option. In addition the Pharmaceutical & Industrial Chemistry degree at UL has a significant component of chemical engineering.

CIT	360
UCC	455
UCD	425 (Chem.Eng. is an option)
UL	400

Chemistry courses

There is some problem classifying chemistry courses as there are very few pure chemistry courses left. Science degrees allow a student to graduate in one or more science subjects, including chemistry. Denominated courses have a fixed focus from the start and these are the majority of chemistry-related courses. In recent years there has been a trend to start or rebadge courses with 'Pharmaceutical' in the title, indicating their relationship to the pharmaceutical industry in Ireland. I have also included Analytical courses in this group. Some courses have a mixture of emphases and have been included in more than one group e.g. Pharmaceutical Analysis and Forensic Analysis (IT Tralee). There are 21 courses in total of various types and the average number of points required is 352. The two without points are new courses in 2011.

AIT	Pharm. Sci.	
CIT	Anal.Chem.&QA.	235
DCU	Anal.Sci.	380
	Chem.&Pharm.Sci.	380
DIT	Chem.Sci.&Med.Chem.	335
GMIT	Chem.&Pharm.Sci.	310
IT Sligo	Pharm.Sci.	270
IT Tallaght	Pharm.Sci.	310
IT Tralee	Pharm.Anal. & For. Sci.	330
	Pharm.Anal. & Env. Sci.	295
	Pharm.Anal. & Cos. Sci.	
LIT	Pharm.&For.Anal.	370
	Drug&Med.Prod.Anal.	275
NUIM	Pharm.&Biomed.Chem.	365
NUIG	Biopharm.Chem.	395
TCD	Chem.&Mol.Mod.	400
	Med.Chem.	475*
	Phys.Chem.Adv.Mats.	410
UCC	Bio.&Chem.Sci.	375
	Chem.Sci.	365
UCD	Med.Chem.&Chem.Biol.	435
UL	Pharm.&Ind.Chem.	360
WIT	Pharm. Sci.	325

Environmental Science courses

Environmental Science (Env. Sci.) courses have a strong chemistry component, though the amount of chemistry in the 4 year honours degrees depends on the institution and all the courses have different emphases. Nine institutions (5 ITs and 4 universities) offer courses and the average number of points required is 337, with the university courses clearly being more in demand.

CIT	Env. Sci. & Sust. Tech.	330
DCU	Env. Sci. & Health	375

DIT	Env. Health	330
IT Carlow	Env. Sci.	310
IT Sligo	Env. Sci.	300
IT Tralee	Pharm.Anal.&Env.Sci.	295
NUIG	Env. Sci.	365
UCC	Env.&Earth Syst.Sci.	370
UL	Env.Sci.	360

Forensic science

Courses in Forensic Science (or some variation on this) have been one of the growth areas in the last few years in the UK and in Ireland. The course in LIT was the first to be offered in Ireland. It can be seen from the list below that six institutions (all in Institutes of Technology) now offer 4 year honours courses in Forensic Science or related areas. The average points required is 354, with the course at GMIT having the highest points. Forensic in the title is the carrot that attracts students through the CSI-effect but there are actually very few jobs in Ireland in Forensic Science. In reality, as you notice from the titles, these are really courses in chemical analysis and thus the students from these courses, which have a strong practical component, have wide employability wherever analysis is required.

DIT	Forensic & Environmental Analysis	335
GMIT	Forensic Science & Analysis	400
IT Sligo	Forensic Investigation & Analysis	340
IT Tallaght	DNA & Forensic Science	350
IT Tralee	Pharmaceutical Analysis & Forensics	330
LIT	Pharmaceutical & Forensic Analysis	370

I have also included biochemistry/biotechnology courses, energy-related courses, sports courses and food-related courses in the general list (Table 4), as all of these have a significant chemistry content and doing LC Chemistry is an advantage in studying them. This also applies to medical. nursing and engineering courses, all of which depend on chemistry. **LC Chemistry is not just useful for studying chemistry but also for many other subjects.**

□

CheMiscellany

But the chemistry's wrong!

It's always annoying if you are a chemist to read an article or a book where the chemistry is wrong. I recently read a detective story by Stephen Booth (*The Kill Call,* 2010, Harper pb) where someone died through suffocation in a closed bunker. This is how he explained it.
"Oxidized metal produces carbon dioxide, and that's lethal in a confined space." (p.523) Ouch!

Rusting iron does not produce CO_2 but it does use up oxygen and in an enclosed space if there was enough iron it could deplete oxygen levels sufficient to cause death, but not by producing CO_2. The familiar demonstration using iron wool in a test tube, showing the % of oxygen in air illustrates the chemistry very well. The water level rises as the oxygen is used up in oxidizing the iron, leaving nitrogen behind.

If you come across examples of faulty chemistry in print, please send them in. There are probably too many examples of chemical-free products to bother mentioning them! The common use of tin foil when talking about aluminium foil always annoys me – my children knew it would wind me up if they used it! PEC

One of the first things a boy learns with a chemistry set is that he'll never get another one. **Anonymous**

The Element Makers: 10

William Hyde Wollaston FRS (6 August 1766 – 22 December 1828)

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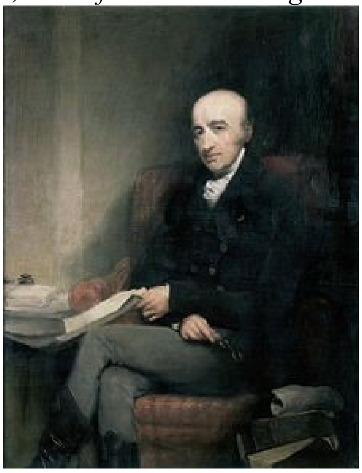
William Hyde Wollaston was born in East Dereham in Norfolk on the 6th of August 1766. His parents were the Rev. Francis Wollaston (1737-1815), priest and astronomer, and Mary Farquier, who were married in 1758. The Rev. Francis Wollaston was to publish an extensive catalogue of the northern circumpolar stars in 1800. He and his wife Mary were to have some seventeen children who survived childbirth, 10 girls and seven boys but of these only two, William and his older brother, Francis John, were to make names for themselves. Francis was the 3rd child and eldest boy, while William was the 12th child and 5th boy of the family.

The early years of Wollaston are shrouded in the fogs of time but it is likely that the children were educated at home. William entered Caius College, Cambridge and it was here that he first came to meet the subject of our previous article, Smithson Tennant, the pair being the only medical students in residence. The backgrounds of the pair were very different: William with living parents and a large group of siblings and very little money and Smithson, alone in the world, but with very independent means. The friendship formed between the pair was to last right up to the death of Smithson in 1815, with the pair collaborating in many enterprises.

While in Caius College William devoted himself more to astronomy, influenced by his father no doubt, than to any other subject but graduated as M.B. in 1787, gaining his M.D. in 1793. Shortly after this Wollaston became Tancred Fellow, a position he kept throughout his life, although he was only a rare visitor to Cambridge.

The time in Cambridge saw Wollaston and Tennant exchanging views on chemical matters but Wollaston held Tennant's knowledge as a chemist in profound admiration and a year or two after this period expressed his despair of ever becoming Tennant's equal. Warburton recounts more ..

"with desires of emulating his distinguished friend [Tennant] he [Wollaston] applied sedulously to chemistry, not making many experiments in his own rooms, but availing himself of a laboratory which his brother Francis had fitted up. Platina even at that time engaged his attention; he made some persevering attempts to fuse it in a Blacksmith's forge, aided by Dr. Pemberton, then of the same College."



The only portrait of Wollaston, made at the insistence of Mrs. Sommerville, whose gatherings he used to enjoy. It shows Wollaston seated in the Royal Society's premises. Like Tennant, Wollaston was particularly averse to having his portrait taken and only agreed to have it done on being threatened with having his invitation to Mrs. Sommerville's gatherings stopped.

Tennant left Cambridge in 1788 and the pair only met sporadically at Royal Society gatherings, finally coming to collaborate seriously once Wollaston went to live in London. One of these meetings was in 1796 when Tennant was experimenting on the combustion of diamond. Wollaston being present, the experiment was underway when Tennant noticed that the time for his daily outing on horseback had arrived and left Wollaston to look after the experiment, while he kept to his daily regime. This careless attitude to experimentation was typical of Tennant and the devotion to the hard slog was to be typical of Wollaston. In spite of this the two men were able to get along over the years.

Leaving Cambridge in 1789 Wollaston set up in practice as a physician in Bury St. Edwards but so few attended his practice that he took himself to

London in 1797 where he practiced medicine, living at 18 Cecil Street just off the Strand.

In 1792 the Jacksonian Chair at Cambridge fell vacant and Tennant applied for it. However, on finding that Wollaston's brother Francis John had also applied, Tennant withdrew his application. In 1813 Tennant was appointed to the post following Francis's retirement as Professor, in order to return to clerical duties, which saw him live as Rector of Cold Norton and Archdeacon of Essex until his death in 1823.

On the 9th of May 1793 Wollaston was elected a Fellow of the Royal Society and in June 1797 made his first contribution to that Society "on gouty and urinary concretions". From this until his death he was to make some 39 contributions to the '*Transactions*' of the Society in a wide variety of topics, from astronomy, optics, mechanics, acoustics, mineralogy, crystallography, physiology and botany. His chemical papers are not included above.

Following the death of his wealthy uncle, West Hyde in 1797, Wollaston received some £8,000 in 3% annuities from the estate in March 1899. This yield of £240 a year left him financially independent and allowed him to quit his medical practice and devote himself full-time to the pursuit of the sciences.

Wollaston and Tennant entered into an agreement in 1800 to undertake a chemical partnership involving the production and sale of platinum items for use in chemistry. They agreed to share equally the expenses and profits of this venture. However, as Wollaston came to be putting more of his time into it over the years they changed the agreement in 1809 so as to give Wollaston 55% of the profits. It is said that by the time of his death Wollaston had gained some £30,000 from this venture.

The pair agreed to keep their collaboration in the venture a secret and so successful were they that it was only in the latter years of the twentieth century that it became known to historians.

During the production of the platinum from the platina ore the waste products of the operation were examined by both Wollaston and Tennant. This examination led Wollaston to find palladium in 1802 and following further investigation of the ore, on June 21st 1804 Tennant announced his discovery of iridium and osmium to the Royal Society and Wollaston added yet another element, rhodium, obtained from the waste products.

In 1802 Wollaston was awarded the Royal Society Copley Medal, which came with a cash gift, worth in today's money £5,000. His friend Tennant was awarded the Medal the following year, with Humphry Davy receiving the Medal in 1804. In all three cases the Medal was awarded for their various papers printed in the Society's *Transactions*.

1802 also saw Wollaston present his first Bakerian Lecture to the Royal Society. This lecture, first given in 1775, is the Society's premier lecture and its award is a recognition of the scientific standing of the recipient. The topic of the Lecture was "Observations on the Quantity of Horizontal Refraction, with Method of measuring the Dip at sea." Wollaston was to give three more Bakerian Lectures: in 1805, 1812 and 1828. The 1805 Lecture was "On the force of Percussion", the 1812 Lecture was on "The elementary particles of certain crystals" and the 1828 Lecture was on "A method of rendering Platina malleable".

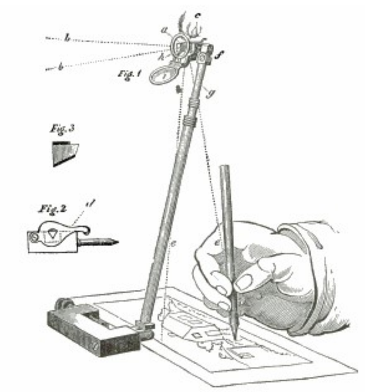
Wollaston was appointed Junior Secretary to the Royal Society on the 30th June 1804, serving in that position until being elected to the Presidency of the Society on the death of Sir. Joseph Banks in June 1820. At the yearly elections in November of the year he stepped down in favour of Sir Humphry Davy.

Following the publication of John Dalton's (6/9/1766 – 27/8/1844) *A new System of Chemical Philosophy*, Vol.1 in 1808, which laid out his atomic theory and gave 'atomic weights', the chemists of the time were quick to investigate the 'new' atoms and to find more accurate figures for the 'weights' than Dalton had been able to. In the immediate years after 1808 Wollaston spent time on this and in 1813 and 1814 presented papers to the Royal Society on equivalent weights. *(Equivalent weight can be taken as the mass of an element that combines with 8 grams of oxygen.)* Wollaston was the first to use the term equivalent weight in its chemical sense and his Nov. 4th , 1814 paper "A Synoptic Table of Chemical

Equivalence" became widely quoted. In it he took oxygen to have a value of 10 and below is given his values for 10 of the elements. (Dalton had based his tables of atomic weights on Hydrogen having a value of one.)

Element	**Equivalent**	**Element**	**Equivalent**
Hydrogen	1.32	Oxygen	10
Carbon	7.54	Sulphur	20.00
Phosphorus	17.40	Nitrogen	17.54
Sodium	29.1	Potassium	49.1
Calcium	25.46	Iron	34.50

(One may amuse oneself by comparing these values with today's figures.)



In 1814 Wollaston invented the camera lucida, an ingenious device which permitted even the least artistic to make faithful copies of scenery or pictures. Herschel, a friend of Wollaston, and famous for his astronomical data particularly in southern Africa used such a device in his mapping of the stars . A small prism is held in an extendable arm which is clamped onto a drawing board. The artist looks along the edge of the prism allowing a direct view of the sketch page through half the pupil and a view of the scene being drawn, through internal Reflection in the prism, to the other half of the pupil. Unlike the earlier camera obscura where a real image was projected onto the paper here the two images are present and superimposed on the retina, and the scene appears to be projected onto the paper.

Wollaston was called upon at various times to give advice to various Government Commissions. In 1814, together with his friend Tennant, he sat on one considering the safety of the new Gas lighting in London, coming to the conclusion "*there was a great necessity for the improvement of some of the works, and a propriety of occasional superintendance of all of them*."
In 1818 and 1819 he served on three Commissions: one on Tables for mariners, another "For inquiry into the mode of preventing forgery of Bank notes" and the third "To consider the subject of weights and measures." In this last his advice led to the adoption of the yard of 36 inches as standard and the gallon as the volume of 10 pounds of water. These Commissions were lucrative, being worth £100 each in payment to Wollaston.

On May 16th 1816 Wollaston read a paper to the Royal Society entitled "Observations and experiments on the mass of native iron found in Brasil." The nine-fold stages of the experiment, to find the proportion of nickel in the sample, shows the care and chemical expertise of Wollaston. The nine steps taken were:

I. *Dissolve a very small portion of the iron in nitric acid.*
II. *Evaporate to dryness.*
III. *Dissolve the oxide of nickel in pure ammonia.*
IV. *Precipitate by use of the triple prussiate of potash.*
V. *Add sulphuric acid to the solution.*
VI. *Evaporate to dryness.*
VII. *Expel the ammoniacal salts by heat.*
VIII. *Dissolves the residuum which is mere sulphate of nickel.*
IX. *By crystallization obtain a state from which the quantity of nickel can be inferred.*

His conclusion from the experiments was that the iron contained 4% of nickel

Wollaston spent his days in experimentation and his evenings at the Royal Society or other learned groups such as the Geological Society, as he had an inexhaustible curiosity about the world. He did, however, make visits outside of London. During the first visit of Tennant to Ireland in 1805, Wollaston was already there and the pair made a joint visit to the Giant's Causeway. About the age of fifty Wollaston took to fishing as a hobby and for the last twelve years of his life spent most of his leisure time involved with the intricacies of casting and fly-tying, become accomplished in the art.

Wollaston was used to carry out his experiments in the greatest privacy, with the minimum of instruments and using the smallest specimens of the substances under examination. On one occasion a visiting foreign scientist on asking to view his laboratory was shown a tray on which lay a blow-pipe, some glass tubes, 2 watch-glasses, a slip of platinum and some test tubes.

Another time after visiting Mr. Children's giant galvanic battery, a friend of Wollaston lamented on the size of battery as being too costly to reproduce. Wollaston took him aside and from his waist-coat pockets produced a thimble, some small electrodes and a connecting platinum wire. From another pocket emerged a small phial of liquid, which he poured into the thimble creating a battery and the platinum wire glowed with a white heat.

By the end of the year 1828 Wollaston became dangerously ill with a tumour of the brain. Knowing that his end was rapidly approaching and not being able to write, he engaged a person to write accounts of his unpublished experiments for forwarding to the Royal Society. Some five papers to the Royal Society arose from this and they show Wollaston's variety of scientific interests. The five papers were:
1. On a method of rendering platina malleable, read November 20th 1828
2. A description of a microscopic doublet, read November 27th 1828
3. On a method of comparing the light of the sun with that of the fixed stars, read December 11th 1828
4. On the water of the mediteranean, read December 18th 1828 and
5. On a Differential Barometer, communicated by Henry Warburton, read February 5th 1829.
The Royal Society awarded Wollaston a Royal Medal for the first paper above.

By the time of his death Wollaston was a very rich man but not possessive of his wealth. Shortly before his death he gave £2,000 to the Royal Society for their Donation fund, which he asked to be used freely in promoting experimental researches. Henry Septimus (1776 to 1857), Wollaston's youngest brother, wrote to him asking that he use his influence in procuring him a post in the Customs Service. Wollaston replied that he had no influence there but included a stock receipt for £10,000 for Henry with the words:
"By the transfer which I enclose I do not deprive myself of any of those comforts or even indulgences to which I think myself entitled for a certain amount of continued exertion and steady economy; and I shall have the satisfaction of having disposed of a part of my property to the last accent, instead of reflecting that I shall not live long enough to have occasion for it."

Since 1812 Wollaston had been a member of the Geological Society, serving as Member of Council on various occasions and as a Vice President, but did not present any papers to that Society in spite of his interest. Some few days before he died, however, Wollaston left £1,000 to the Geological Society to fund a medal to honour outstanding geological contributions. In 1835 the gold medal cost £10 and the gift going with it was £22. From 1846 to his death in 1866 a Fellow of the Society, Percival Norton Johnson, added to the fund to allow the medal to be cast in Palladium, first isolated by Wollaston, but this reverted to Gold again after this date.

The Wollaston Medal of the Royal Geological Society

Wollaston died on the 22nd of December 1828, without having married, and was buried in Chiselhurst Churchyard, Kent.

Dr. William Henry concluded his remarks on the life and character of Wollaston with the following:
"He was remarkable, too, for the caution with which he advanced from facts to general conclusions; a caution which, if it sometimes prevented him from reaching at once the most sublime truths, yet rendered every step of his ascent a secure station from which it was easy to rise to higher and more enlarged inductions."

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Smithson Tennant: the innovative and eccentric eighth Professor of Chemistry, Melvyn Usselman, Dept. of Chemistry, University of Western Ontario.
Philosophical Transactions of the Royal Society, London; various years. □

ChemTips: #12 Balancing equations

Formulae first

Going from word equations to chemical equations assumes that pupils understand and can write and use chemical formulae. Thus formulae must be taught first and the differences between NO_2, N_2O_4 and $2NO_2$ made clear. This can be done using molecular models, following on from the last ChemTips on introducing atoms and molecules, elements and compounds. (*CinA!* #89, 2010, p.19) For covalent molecular compounds models are the ideal way to relate formula to structure and name. The name and formula of simple molecular compounds are directly related - the name tells you the formula and vice versa.

e.g. carbon dioxide, CO_2
dinitrogen tetroxide, N_2O_4
disulfur dichloride, S_2Cl_2

Organic compounds have their own naming system, which also connects the name to the molecular structure.

This is not true for ionic compounds and the formula for ionic compounds is the empirical (i.e. simplest) formula - it only tells you the simplest ratio between the component atoms. It does not tell you the structure of the substance and it does not represent a molecule. Thus sodium chloride is NaCl, calcium carbonate is $CaCO_3$, iron(III) oxide is Fe_2O_3. The name for an ionic compound has the names of the component ions only and the formula is worked out from the charge and formula of the ions. Thus iron(III) oxide is composed of Fe^{3+} and O^{2-} ions, so we need 2 Fe^{3+} to balance 3 O^{2-} ions in the simplest formula. You can demonstrate this using plastic bricks or jigsaw cards of different size and combining power. However, what you get is the simplest formula not a molecular formula for ionic compounds. Formula alone does not tell you either the molecular structure (for molecular substances) or the crystal structure (for ionic substances) and this must be determined separately.

Balancing equations

There is a lot of evidence that balancing equations is one of the most difficult topics in chemistry and many pupils never get it - they just try to learn off the balanced equation as a whole, without understanding how to do it. Formulae and equations are part of the symbolic and abstract part of chemistry and thus are difficult for beginners. We need to make the idea more visible and concrete by using models to get over the idea of balancing equations, before doing it symbolically.

In balancing a chemical equation we use the idea of conservation of mass (and thus atoms) - matter is not created or destroyed in a chemical reaction. This means that atoms are not lost or gained in a reaction, just rearranged into different substances. We must have the same number of atoms of each element (and thus the same mass) at the start of a reaction (in the reactants) as we have at the end of the reaction (in the products). Balancing an equation means writing the number and formulae of the reactants that we start with (on the left hand side, LHS, of the equation) and on the other side the number and formulae of the products. (on the right hand side, RHS, of the equation). The equation is balanced (i.e. correct and satisfying the conservation of mass) if we have the same number and type of atoms on the LHS as we have on the RHS. However, the atoms must be organised into the appropriate molecules involved in the reaction e.g. O_2 not O.

A simple equation balance

We can introduce this idea with a simple two-pan balance and plastic bricks. You could construct a simple balance (one with two pans) using two plastic or paper plates, string and a wooden rule or rod. However, it is better to use have an old two-pan balance or the simple balances used in primary schools, as shown in Figure 1. The pans should be identical and the when the pans are empty the balance arm should be horizontal. The simpler the balance the better, as we want to show visually whether one side is heavier or lighter than the other and when they balance.

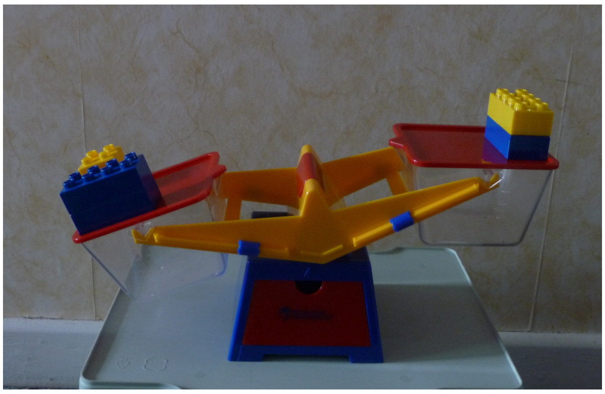


Figure 1 A simple equation balance – models representing oxygen and hydrogen molecules on one side, a water molecule on the other

Let us take the typical and familiar reaction between hydrogen and oxygen gases to give water.
First write a word equation.
Hydrogen gas + Oxygen gas → Water
Write the formulae of the molecules underneath.
Hydrogen + Oxygen → Water
H_2 O_2 → H_2O
Now use the building blocks to make models of the reactants and products (see Figure 1). Place the model of H_2 (2 small yellow bricks) and O_2 (two double blue bricks) on one side of the balance and the model of water on the other (2 yellow single and 1 blue double brick).
Does it balance? No – the LHS is heavier than the RHS.

One side is heavier than the other so it tells us we have too many atoms on one side. Ask the class how many atoms of what sort we need to add to one side or the other to make it balance. We have 2 H (as H_2) and 2 O (as O_2) on one side but only 2H and 1 O on the other side (as H_2O). The RHS is lighter and we need to add 1O to balance it but the O atom isn't in the word equation - we must add 1 H_2O to the right side to provide 1 O and then it is too heavy on the RHS (see Figure 2).

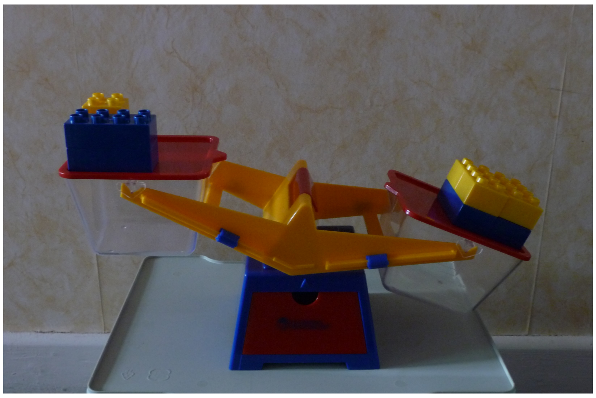


Figure 2 A water molecule is added to the RHS

How do we get it to balance now? We have to add 2 H atoms as 1H_2 molecule to the LHS and now it balances (see Figure 3). We have the same number of hydrogen and oxygen atoms on each side of the balance (equation), so we have the same mass on each side and it balances.

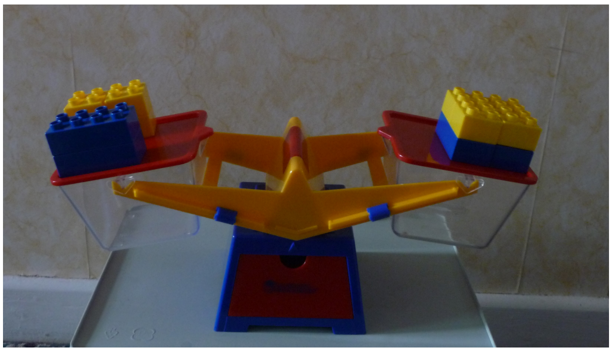


Figure 3 The balanced equation

Complete the symbol equation to balance it.

Hydrogen + Oxygen → Water
H_2 + O_2 → H_2O
$2H_2$ + O_2 → $2H_2O$
4 H + 2 O → 4H + 2O

You can repeat this exercise again using molecular models, making sure you use the same number of connectors (bonds) of the same mass. Molymod models are ideal for this.
H-H + O=O → 2H-O-H

What we are trying to do is to give a concrete, tangible picture of what balancing an equation means – you can see what balancing means by using a balance. Once your pupils have the idea you can continue using first models alone and then symbols on paper.

Figure 4 illustrates the starting position for balancing the equation between iron or aluminium and chlorine. We start with a triple block (an iron atom) and 2 single blocks joined representing a chlorine molecule. On the RHS we have one triple block (iron) joined to three single blocks (chlorine).

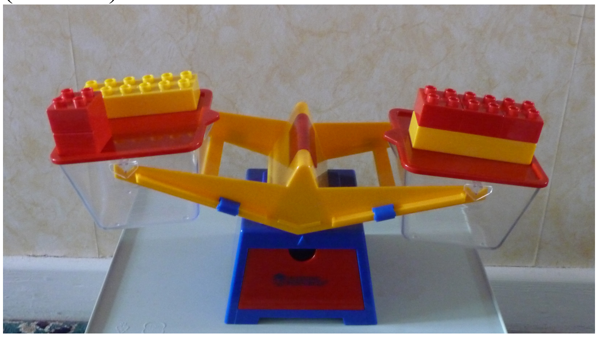


Figure 4 The unbalanced reaction

Iron + chlorine → Iron(III) chloride
Fe Cl_2 $FeCl_3$
This is unbalanced – the RHS is heavier than the LHS. Once again it is balanced in steps, asking your pupils how to do it. You can of course start to add atoms/molecules to the LHS or RHS as long as you end up with the same number on both side. Iron must be added as a triple block and chlorine as two single blocks joined. Figure 5 shows the final solution: we need 2 iron atoms and three chlorine molecules (Cl_2) on the LHS to balance two $FeCl_3$ molecules on the RHS.

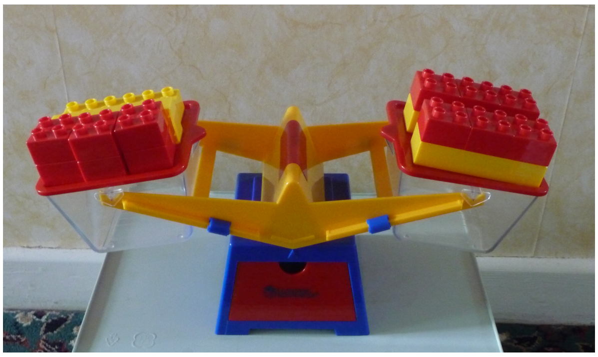


Figure 5 The balanced reaction

The balanced reaction would be:
$2\,Fe + 3Cl_2 \rightarrow 2FeCl_3$

Do this exercise again for other reactions, e.g. the reaction of magnesium and oxygen to give magnesium oxide.
Magnesium + Oxygen → Magnesium Oxide
$\mathbf{Mg + O_2 \rightarrow MgO}$

Add 1 double block representing magnesium and a model of an oxygen molecule (two double blocks) on one pan and a model of a magnesium oxide on the other (1 block of each). Does it balance? The LHS is heavier as it one extra O atom. It we add an O atom to the RHS it balances but the O is on its own. To balance it we must also add a magnesium to each side and combine the Mg and O together on the RHS. Then we have a balanced reaction with the right formulae on each side.

Magnesium + Oxygen → Magnesium Oxide
$Mg + O_2 \rightarrow MgO$
$2Mg + O_2 \rightarrow 2MgO$
$2Mg + 2O \rightarrow 2Mg + 2O$

MgO is not a molecule so it is best not to use molecular models or you will establish some wrong ideas. The principles involved in balancing the equations are the same whether we have elements or compounds, covalent or ionic compounds involved.

Other examples you could use are (these are the balanced equations):
$H_2 + Cl_2 \rightarrow 2HCl$
$3H_2 + 2N_2 \rightarrow 2NH_3$
$2HCl + Na_2O \rightarrow H_2O + 2NaCl$
$2HCl + CaO \rightarrow CaCl_2 + H_2O$
$2Fe + 3O_2 \rightarrow Fe_2O_3$

For each reaction first write the word equation; then write the formulae of the compounds underneath. Make models of the compounds using the plastic blocks and load each side of the balance. Then decide what to add to each side to make it balance - if atoms are added they must be part of one of the substances in the equation, they can't be on their own! Finally, write the balanced chemical equation under the word equation. For the molecular reactions (not those involving ionic compounds or ionic solutions) make molecular models as well and demonstrate that if you have the structure and number correct, then the balance will balance!

Once your pupils have got the idea you should be able to move on to writing the word equation, the unbalanced equation underneath and then balancing the equation on paper without using the models and balance. When they can do this consistently, they have got it! The models have made the abstract concept concrete and the invisible visible, and once they 'get' the underlying idea they can move on to think symbolically.

States of matter - do they matter?

When we introduce balancing formulae and equations we don't usually use states of matter symbols, on the principle that it's best to start simple and add complexity later. However, $H_2O(s)$, $H_2O(l)$ and $H_2O(g)$ ARE NOT THE SAME - they are as different as ice, water and steam. If you just write H_2O it is ambiguous. To connect our symbolic equation to the real world we should also ask what state the substances are in - solid (s), liquid (l), gas(g) or in aqueous solution (aq). Thus our balanced equation for burning hydrogen and oxygen to produce liquid water above becomes:

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

When we say water it is not ambiguous but the formula H_2O is.

Confusing names

Another area of confusion is when we talk about oxygen and hydrogen. Do we mean the elements, the atoms, the molecules? We should say hydrogen atom (H) or hydrogen gas or hydrogen molecule (H_2) to make it clear. Hydrogen is the name of the element but the name of the molecule is dihydrogen - the name tells you that 2 H atoms are connected to form a molecule. Ordinary oxygen gas is dixoygen, O_2, while the allotrope ozone is trioxygen, O_3 (also known as ozone).

Complex or molecular ions

All the examples above are binary compounds of just two elements and do not contain any complex ions, like sulphate or hydroxide or nitrate. Part of the problem here is recognising sulphate, SO_4^{2-}, as a unit, where all the atoms are joined together in a molecular (complex) ion. When we have more than one ion this is clear as we put brackets around it e.g. $Ca(OH)_2$ but it is not as obvious in NaOH that OH is a unit. It might be helpful when starting to put brackets even around single complex ions, so that it is clear that we are dealing with a unit. Thus we could write $K_2(SO_4)$ rather than K_2SO_4 to make the point. When balancing equations we must treat the complex ions as a unit, like a molecule, and they can only be added as a unit.

In the example below I have added the brackets for clarity.

Potassium hydroxide + Sulphuric acid → potassium sulphate + water

$K(OH) + H_2(SO_4) \rightarrow K_2(SO_4) + H_2O$

Does it balance? No – we have an extra K on the RHS and an extra H on the LHS. We can only add them as a K(OH) unit. When we do so the equation is still not balanced – it is now short 2 H and 1 O (1 H_2O) on the RHS.

$2K(OH) + H_2(SO_4) \rightarrow K_2(SO_4) + H_2O$

2 K 2O 2H 2H 1S 4O 2K 1S 4O 2H 1O

We need to add 1 H_2O on the RHS.

$2K(OH) + H_2(SO_4) \rightarrow K_2(SO_4) + 2H_2O$

It is now balanced and we can remove the brackets.

$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

Conclusion

This idea is another example of moving from the concrete and visible to the abstract and invisible, from the use of physical models to the use of symbols. Often in teaching we jump straight into the symbolic representation of formulae and equations and our pupils do not grasp what the symbols mean. By introducing the ideas of atoms and molecules, elements and compounds, formula and equations using simple models - first plastic building blocks and then molecular models – we are laying a solid, in fact a concrete, foundation on which to build the superstructure of abstract ideas represented as symbols. We need to teach a systematic approach to balancing equations, working through examples step by step until the penny drops, so that our pupils understand how to do it not merely how to memorise a limited number of misunderstood examples. Let us go back to first principles and teach for understanding – but let us also start with concrete models before we launch into abstractions and symbols.

□

The use of Humour in the Classroom

Marie Ryan

In many teacher training programs across the country, one of the last slices of information that they bestow onto newly qualified teachers is "Don't smile before Christmas!" Veterans of the chalkboard jungle know the dangers that lurk behind the inquisitive faces that greet a new teacher on the first day of school. Yet, the need for control and confidence in the classroom does not preclude the use of humour as an appropriate and effective tool for managing students and helping them to learn in a challenging environment.

The use of humour in education can be a powerful and enjoyable tool, ultimately helping students learn. It can make the process of learning more meaningful and help attain and sustain the attention of the class. The effective and appropriate utilisation of humour has a number of benefits for both teaching and learning. Berk (1996, 1998) states that humour has the ability to decrease students' anxiety, improve their ability to learn, and boost self-esteem. Humour can help to strengthen the student/teacher relationship, reduce stress, make a topic more interesting, and, if relevant to the subject, may even enhance recall of the material (Friedman et al., 2002). This, in turn, can encourage a more receptive learning atmosphere.

From my own teaching experience, I know that it is one thing to read about what research has discovered but it is a great deal more difficult to implement these discoveries into your everyday teaching. For this reason, some of the benefits of incorporating humour in your teaching along with examples of how they can be achieved are illustrated below:

1. Humour Builds Relationships and Enhances Communication

A great deal of research supports that humour is seen as a key attribute for successful teachers. Bryant et al. (1980) cite a study indicating that a sense of humour is one of the most important attributes student's want from teachers. Humour is effective as a route for teachers to appear more approachable, down-to-earth, and friendly. It is vitally important that students recognize their teacher as approachable as they should not be afraid to ask them questions.

A simple way to employ humour in your teaching is to use a joke or anecdote. The following example illustrates how a relevant joke can inject humour into your teaching, while still stressing the point you are trying to convey to your students:

A neutron walks into a bar; he asks the bartender, 'How much for a beer?' The bartender looks at him, and says 'For you, no charge.'

2. Humour for reducing stress

Humour in the classroom relaxes students and makes the lesson more interesting. But, are there any areas in which humour has notable benefits for teaching and learning?

Friedman et al., (2002) state that humour is especially important and effective before examinations when students are often "stressed out". They also found that the examinations themselves should have humorous questions to alleviate some of the tension. Berk (2000) found that humorous examination questions may reduce student stress. Berk (1998, 2000) further suggests several strategies for injecting humour into exams, one of which is to add an irrelevant choice to some questions of a multiple-choice test. The choice would be so outrageously funny that no student would possibly consider it a correct answer.

The following is an example of one such multiple choice question:

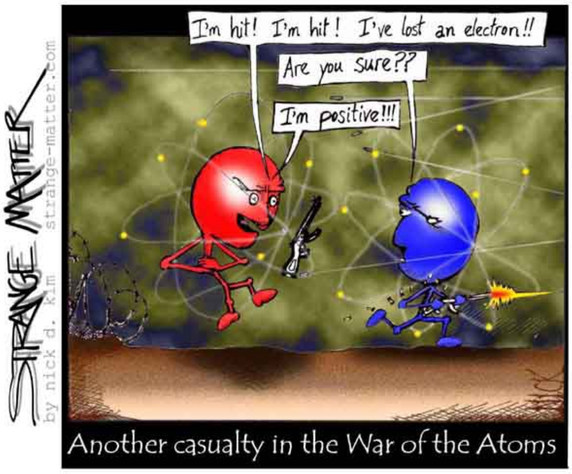
Q*) Who created the first periodic table of the elements?*

a) **Pierre Curie**
b) **Dmitri Mendeleev**
c) **Jack Sparrow**
d) **Robert Boyle**

Stress overloads the brain with powerful hormones that are intended only for short-term duty in emergency situations. Their effect may damage and kill brain cells, thus reducing student performance. The 'Jack Sparrow' opinion as shown above should give students a giggle and help alleviate some of the stress they may be experiencing.

3. Humour Makes a Course More Interesting and Enhances Retention and Recall of Information

A great body of research supports the thesis that humour makes the course more interesting to students (Whisonant 1998; Trefts and Blakeslee 2000). Even a supposedly boring topic can be livened up with interesting and humorous examples. Trefts and Blakeslee (2000), find that humour is a good way of making a boring subject more interesting, not only for the students, but also for the teachers. Korobkin (1988) found that classroom information is retained longer when presented in a humorous manner. One way in which this can be achieved is through the use of science cartoons. The following is an example, and many cartoons are available on the internet:



Source: from Google 'science cartoons'.

Research conducted by Powell and Andresen (1985) found that humour is a way of getting students to pay attention, and it enhances the recall of information. Think about it: the humorous pictures and illustrations utilised in this article will most likely be remembered for a greater length of time than the article itself!

Numerous studies in the field of advertising have noted that humour is the most effective tool for enhancing recall of advertisements. I have noticed this myself in my own experience and also from the advertisements that students make reference to. For example, 'them bones them bones need calcium'. Similar to aspects of the 'hidden curriculum' as highlighted by Lynch (1989), years - some would say days - from now, students will have forgotten much of what we teach them. However, important points which were illustrated in a humorous way are quite difficult to disregard and forget. Kaplan and Pascoe (1977) claim that humour that is relevant to the subject material enhances the retention of the concepts being taught. The science cartoon shown above are relevant to a particular area of science. I believe that the first cartoon is particular effective as it displays atoms in a manner in which students can comprehend. The war- like image assists students in understanding that if one atom loses an electron, the other atom gains it, resulting in the first atom becoming positively charged. Students should be encouraged to look for mistakes or erros in a cartoon or drawing, and may be more inclined to learn the correct terminology since they themselves 'spotted the differences', and rote 'textbook learning' wasn't involved. It is my belief that students should be active participants in their own learning, not mere passive consumers of information. Utilizing humour in your teaching is one method to achieve this.

Despite these benefits, many teachers fear using humour as a teaching strategy as they believe that humour will only cause unacceptable behaviour in students and create unnecessary and unwelcome interactions between them. While I accept that humour may create a certain degree of undesired student interactions, it can also be used to curtail and terminate misbehavior, while still retaining the relaxed and receptive learning environment of the classroom, which students learn best in. For example in my opinion, the best way to deal with students who are talking during class is to first try some humour. Nasty retorts to students often lead to confrontations, which can escalate and adversely affect the student/ teacher relationship and the overall learning environment. To avoid the latter repercussions of the traditional classroom management techniques, you might try: *"What! I hear voices again. My psychiatrist told me that if I keep taking my Prozac the voices will go away."* Or, *"I have an inferiority complex so please don't speak while I'm speaking. I am afraid that the class will prefer your teaching over mine."*

Many teachers, just like the majority of the adult population, have conformed to society's norms where by using humour in any business organisation, be it a school or an office, is unacceptable and inappropriate. Bee (2000) highlighted that from an early age, children learn through active engagement with and exploration of their surroundings. They learn through play and what amuses them. Yet, a few rare individuals, including some teachers, keep playing after they have 'grown up' and incorporate elements of fun into their work. Many of the great contributors to our world, like of Albert Einstein, Beatrix Potter, Thomas Edison and Alexander Graham Bell are exemplars of individuals who continued to play and have fun after they had 'grown up'. Without these great people and the retention of their creative, imaginative, and inquisitive self, many of the great inventions and literatures would not exist. It is, as Bee (2000) encapsulates it, the *"active engagement with and exploration of their surroundings"* that allowed the individuals mentioned above to create and produce such enduring and valuable pieces of work. Their child-like state had not been eradicated by their entering into adulthood and thus, they were able to work through the innumerable unworkable, so-called "bad" ideas which they had to overcome to achieve the creations to which we associate them with today. In the words of Plato *"Do not train students to learn by force & harshness; but direct them to it by what amuses their minds, so that you may be better able to discover with accuracy the peculiar bent of the genius of each."* When the audience laugh, the learning lasts. In our case the audience are the students and they need to feel the information that is introduced to them. When they learn and laugh, they do that!

It is natural that many teachers are apprehensive about incorporating humour into their repertoire of teaching techniques, especially when teaching a class full of teenagers. They have a different sense of humour to their teachers, and as such many teachers are fretful that they will lose some of their credibility if they use a "bad joke". I believe it is eminently possible to 'fail' in front of others without losing credibility. For example, all too often students neglect to associate their teachers with being 'human' or having a life outside of school. The numerous conversations that occur on a Monday morning after a teacher was spotted in 'A-wear' purchasing a top, OMG!! The occasional crack at a joke, even if perceived as a failure, allows the students to visualise their teacher as somewhat 'normal' and maybe even approachable when a problem does present it. As the learning environment becomes more relaxed and receptive to the students, it enables them to utilise much more of their creative self. They begin to recognise that failure in itself is not a bad thing.

I myself witnessed that by incorporating humour into my teaching: it assisted students in becoming more adventurous and inquisitive when conducting science investigations. They were more inclined to ask the 'why?' questions as opposed to merely accepting the answers which theory provided them with. After all, without failure many of the great inventions and discoveries would not exist. Did you know that Thomas Edison tested no fewer than ten thousand light bulb filaments to find one that neither blew out nor burnt up? When told "You failed ten thousand times?" He replied "Of course not. I found ten thousand things that don't work. Cool huh?" (Or nineteenth century words to that effect). Why then are we as teachers, curtailing the use of humour in the classroom if it has the added benefit of increasing students' creative and inquisitive nature, without which the great inventions and discoveries of the future may not have come to fruition.

Additionally, many teachers rule out the use of humour in their teaching as they deem themselves unable to utilise it appropriately in the classroom, perceive that humour is unacceptable in their teaching or simple regard themselves as "not funny". **Don't say that you aren't funny.** Anyone can get laughs if you prepare ahead of time and are willing to put yourself out there. By keeping the following simple rules in mind, you can use humour in the classroom to help your students learn, even if you're not a natural comedian:

- Gather information about your audience. How old are they? Is it a mostly male or female audience or mixed? What common knowledge will they have (in other words are there common topics they will all be familiar with and enjoy)? Always be thinking about these things when figuring out how and what to present to them. For example, in the first section of one of the TY Science Forensic Science modules, there is a 'pattern recognition' exercise. Instead of using only the 'spot the difference' example provided, try using celebrities with which the students are familiar with. The following are examples of humorous spot the differences: Robert

Patterson (In Twilight) versus Lord Volemort (In Harry Potter) or Jedward.

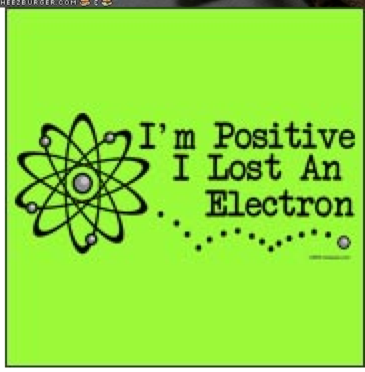
Students still achieve the aim(s) of the lesson but in a more enjoyable and interesting manner.

- Try to think about topics in your lesson that can be utilized humorously. Topic-oriented humour is very powerful, as it truly accomplish two things at once: it will grab the attention of your students and help them remember the main points of the lesson. For example, if the lesson was on human nutrition and the human dental formula, try inviting the students to make a song or poem about what the letters stand for. Here is one such illustration: I 2/2 C 1/1PM 2/2 M 3/3. **I C P**aul **M**orrissey **M**ooning. Paul Morrissey in this illustration was a boy whom a lot of the girls in one particular class liked. The illustration also incorporated text language in the form of using 'c' for the word 'see' and an added element of harmless humour in using the word 'mooning'. A laugh was had by all in learning the human dental formula. It's hardly surprising that when a question appeared on the human dental formula in a Christmas test, only one student out of sixteen answered it incorrectly.

- Look for funny props, newspaper clippings, internet pictures, stories or anything else that can be incorporated into your lessons. It is especially powerful if it has to do with the topic that you are discussing with your audience. Be ready to open your lesson with some of these things to establish that humour and education both are important to you. This will help direct attention toward you and bring up the mood of the room as a whole. For example:

To most people solutions mean finding the answers. But to chemists solutions are things that are still all mixed up.

If you have access to overhead or data projectors, try including some humorous slides in your slideshow, as these will help illustrate your point. For example, if teaching about concave and convex lenses, try using a funny picture to help students understand and remember the difference between them.



Be ready for some of your attempts at humour to fail. Some of them will fail, but this in itself actually provides a way for you to be funny in commenting on how bad your attempt at humour was. Saying something like: "Wow...that one bombed" or "Ok...back to the drawing board with that joke" will give the students another opportunity to laugh, and more often than not, you will at least get some smiles from the students. Think of it this way - is it not better for a few seconds to be dedicated to laughter, which may result in a more alert and responsive class, rather than having no humorous moments but a class full of mostly 'switched off' students?

Some of the funniest things you can do will occur when you forget about trying to be professional, lighten up, take a risk and just go with your idea. You can have a laugh and still remain a figure to be respected. I have used humour many times with a high amount of success but also there have been moments of complete failure with blank un-amused faces wondering has our teacher 'lost it'. Nonetheless I never lost the respect of the students and instead a gained a class full of 'switched-on' alert students.

In summary: The effective use of humour has a wide range of benefits for both teachers and students, these include opening the gates to teacher/student communication, helping students realise that the teacher is approachable and human, reducing students' anxiety, improving their ability to learn, boost self-esteem, strengthening the student/ teacher relationship, reducing stress, making a topic more interesting, and, if relevant to the subject, even enhancing recall of the material. Humour must be utilized at appropriate times, this includes finding the right balance between instruction and wit. Humour is not a strategy to be employed to gain popularity but one to keep students alert and engaged. The humorous material used must be sensitive to the culturally diverse nature of current Irish classrooms and must not be regarded as inappropriate by any of these cultures present, as this would promote greater damage than good. This means that racist, crude or sexist jokes are out.

Keep up to date with the latest trends and 'big thing' in students lives, for example, the TV series that they all talk about. Try incorporating examples from television programs that assist you in getting you point across about a topic you are teaching. If students make a mistake or you have lost control of the class, try using Jedward's famous expression of 'OMG you guys' (or similar expressions to which students are familiar with). I am sure this will lighten the mood and assist you in grabbing the attention of your class and maybe to your surprise the respect of your students.

The following are a few useful resources on the topic of humour in education:

Science Cartoons and Pictures

http://www.sciencecartoonsplus.com/pages/gallery.php
http://www.offthemark.com/science/science02.htm
http://www.benitaepstein.com/science%20cartoons/science.html
Type in 'Science Cartoons' into or 'Education Humour' Google images.

Science Anecdotes

http://www.physlink.com/fun/jokes.cfm
http://www.anecdotage.com/browse.php?term=science
http://www.xs4all.nl/~jcdverha/scijokes/10.html
http://www.suslik.org/Humour/Education/science.html#

Humour articles

http://iteslj.org/Techniques/Chiasson-Humour.html
http://www.cdtl.nus.edu.sg/link/mar2006/tm3.htm
http://www.faculty.armstrong.edu/roundtable/4717458.pdf

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6. Bryant, J., Comisky, P.W., Crane, J. S., and Zillmann, D. (1980), "Relationship between college teachers' use of humour in the classroom and students' evaluations of their teachers," *Journal of Educational Psychology*, 72, 511-519.

(Contd. On p.51)

Conference Reports

29th ChemEd-Ireland, 9th October 2010,
Dublin Institute of Technology, Kevin Street, Dublin

Michael Seery and Claire Mc Donnell

The theme of this year's conference, held at Dublin Institute of Technology, was **Motivating and Engaging Chemistry Students**, and included a plenary lecture on this topic from Dr Jane Essex, University of Keele, entitled "*Teaching Students of Differing Ability"*. Jane outlined several strategies for teaching classes when there is diversity in capabilities in the student group and provided examples of resources and activities that she has found to be useful in this regard. Dr Tim Desmond, the Chief Examiner for Chemistry, presented the second plenary lecture on his observations on student performance in the Leaving Certificate exam at Ordinary and Higher Levels. He provided a very useful review of the topics and types of questions that students usually perform well in and also highlighted the areas that often cause difficulty.

Dr Tim Desmond presented his observations on performance in Leaving Cert Chemistry.

Lunch in the Camden Court Hotel.

After a break for coffee and a visit to the exhibition stands and posters, participants attended one of the five parallel workshops listed below:

- **Reflecting on Teaching Practice,** facilitated by Martina Crehan and Marian Fitzmaurice, DIT Learning, Teaching and Technology Centre.
- **Incorporating Web 2.0 in Teaching,** facilitated by Fionnghuala Kelly and Muireann O'Keeffe, DIT Learning, Teaching and Technology Centre.
- **Preparing Students For Entry Into Scifest And Young Scientist Competitions,** facilitated by Michelle Dunne (St Joseph's College, Lucan) and Sheila Porter (SciFest Project Manager, Intel).
- **Resources for Teaching the Particulate Nature of Matter,** facilitated by Peter Childs and Maria Sheehan, University of Limerick.
- **Context-based Learning Materials (Forensic & Environmental Chemistry and Nanotechnology Lab Activities),** facilitated by Peter Brien, Caoimhe Ní Neill, Aoife Power, Michael Seery, Patrice Behan and Christine O'Connor, School of Chemical and Pharmaceutical Sciences, DIT.

Workshops on Incorporating Web 2.0 in Teaching

and on Context-based Learning Materials.

Following lunch in the Camden Court Hotel, Sheila Porter (SciFest Project Manager, Intel) and Aisling Judge, a former Young Scientist winner, provided information on the SciFest festival of science and the Young Scientist exhibition respectively and gave some very useful advice on how best to support students who enter either of these competitions. This was followed by a presentation by Dr Peter Childs and Dr Maria Sheehan, University of Limerick, who spoke about their research on the development of "*ITS Chemistry",* a module designed to teach the Particulate Nature of Matter and The Mole Concept at Leaving Certificate level. These afternoon presentations dealt with topics that had also been explored in two of the parallel workshops before lunch. However, the formats differed significantly in that the workshops provided an opportunity for discussion led by the participants' specific interests and for hands-on experience of using teaching resources.

Aisling Judge, former Young Scientist winner.

Dr Maria Sheehan and Dr Peter Childs presented their "ITS Chemistry" module.

The day finished with three short talks; the first was from Peter Jackson who outlined the support and resources available from the Professional Development Service for Teachers, the next was from Dr Odilla Finlayson, Dublin City University, who summarised the ESTABLISH project which promotes inquiry-based science education and the final speaker was Dr Brian Murray, Institute of

Technology Tallaght, who represented the Institute of Chemistry of Ireland and presented plans for the International Year of Chemistry 2011. The day finished on a very pleasant note with the presentation of the Institute of Chemistry of Ireland Schools Chemistry Newsletter prizes. Dr Michael Seery did not give his scheduled presentation on class websites and podcasts using Google sites during the afternoon session due to time constraints but his presentation is available via the website listed at the end of this report.

The conference was well attended with over 80 participants. Feedback from the evaluation forms was very positive and all presentations and workshops received favourable comments. Participants reported that their main reasons for attending the meeting were to get ideas and resources to use in their teaching, to meet other teachers and to recharge batteries and renew enthusiasm. Several participants would have liked to have more than one workshop on the programme. All workshops received very positive feedback, and participants especially liked the hands-on approach that provided ideas to take back to the classroom. Some participants highlighted the value of the informal aspects of the day, such as talking over coffee and lunch, and would have liked more informal discussion time. Suggestions for future topics/workshops included; overcoming mathematical difficulties in chemistry, lab organisation and stock control, lab safety, managing large numbers of students in the lab, and ideas for transition year classes.

The conference was supported by the Institute of Chemistry of Ireland, the Society of Chemistry and Industry, the Royal Society of Chemistry, the Professional Development Service for Teachers and Dublin Institute of Technology.

All of the presentations and resources, as well as photos from the day, are available to download from the conference resources page at the website http://dit.ie/chemed/. The Proceedings will appear in *Chemistry in Action!* in issue #93.

The 2011 conference will be in University College Cork on Saturday October 22^{nd}. and is being organised by Dr Declan Kennedy. This will be the 30^{th}. conference in this series and will be part of Ireland's IYC 2011 events.

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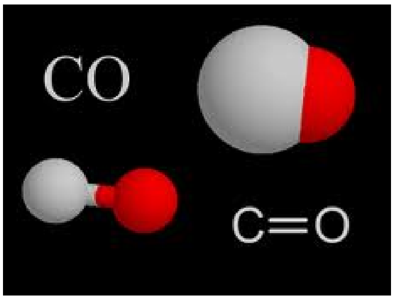
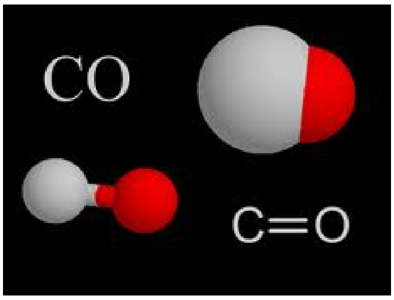
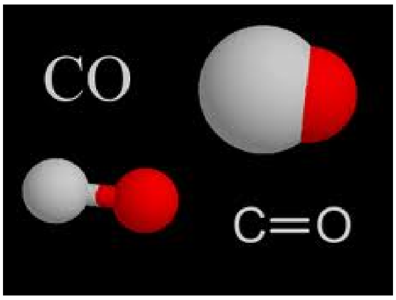
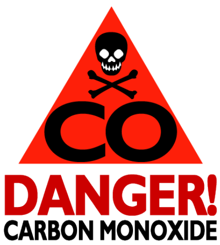






The silent killer: the curse of carbon monoxide, CO

Every year people in Ireland die from breathing a colourless, odourless gas – carbon monoxide, whose initial symptoms resemble the flu. In the USA hundreds of people die each year and thousands are hospitalised from carbon monoxide poisoning. Carbon monoxide is a silent killer as it does its deadly work before people are aware of its effects.



Going to sleep in a room containing a high enough level of CO can prove fatal. When any carbon-based fuel (oil, coal, gas) is burnt in air it produces carbon dioxide. But if there is insufficient air then complete combustion does not occur and carbon monoxide is formed. This can occur if a heater or fire is used in a poorly ventilated room (the fire uses up the oxygen) or if the boiler is not properly maintained. S simple example of this is a Bunsen burner – a hot, blue flame indicates complete combustion but as the air supply is reduced the flame becomes yellow due to unburnt particles of carbon – incomplete combustion. Faulty boilers are the usual cause of CO poisoning as in the recent case in Kinsale.
Of course, CO_2 cannot support life and high levels of CO_2 can prove fatal also – but much higher concentrations are needed than for CO. We would suffocate in an atmosphere of CO_2 (or indeed any gas) due an absence of oxygen. CO poisons in the presence of oxygen because it competes with O_2 for the iron in haemoglobin (in red blood cells), which transports oxygen to the rest of the body and supplies the energy to keep us going by 'burning' carbon-based food. The O_2 molecule forms a weak bond to the iron in haemoglobin, strong enough to hitch a ride in the red blood cells, but weak enough for O_2 to be released in the muscles. CO bonds more strongly than O_2 to iron, probably because CO is slightly polar even though both O_2 and CO are π-bonded molecules. The equilibrium constant for forming carboxyhaemoglobin (HbCO) is ~200 times the constant for forming oxyhaemoglobin (HbO2). So just when CO is just 1/200 th of the O_2 concentration it competes equally for haemoglobin. This means that oxygen does not get to the muscles and the body slowly shuts down from internal suffocation.

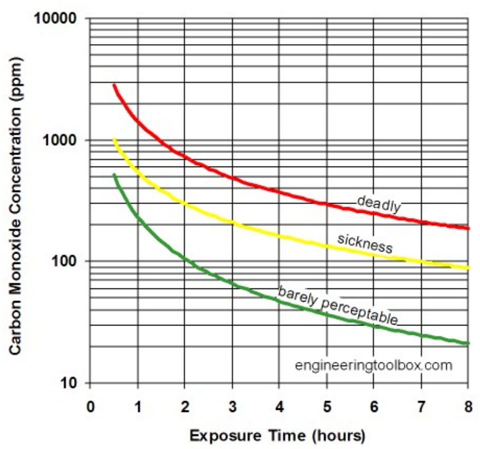


Figure 1 Toxicity of carbon monoxide

Figure 1 shows the effects of CO at different concentrations and exposure times and Tables 1 & 2 show the effects an symptoms at different CO levels. The difference in toxicity between CO_2 (390 ppm, 0.039% in air) and CO (0.1 ppm in air) is shown by the allowed safe workplace levels for an 8 hour day: 5,000 ppm (0.5%) for CO_2 and 35 ppm (0.0035%) for CO.

100 ppm	.01%	Slight headache in two to three hours
200 ppm	.02%	Slight headache within two to three hours
400 ppm	.04%	Frontal headache within one to two hours
800 ppm	.08%	Dizziness, nausea, and convulsions within 45 minutes. Insensible within two hours.
1,600 ppm	.16%	Headache, dizziness, and nausea within 20 minutes. Death in less than two hours.
3,200 ppm	.32%	Headache, dizziness and nausea in five to ten minutes. Death within 30 minutes.
6,400 ppm	.64%	Headache and dizziness in one to two minutes. Death in less than 20 minutes.
12,800 ppm	1.28%	Death in less than three minutes.

Table 1 Effects of different CO concentrations

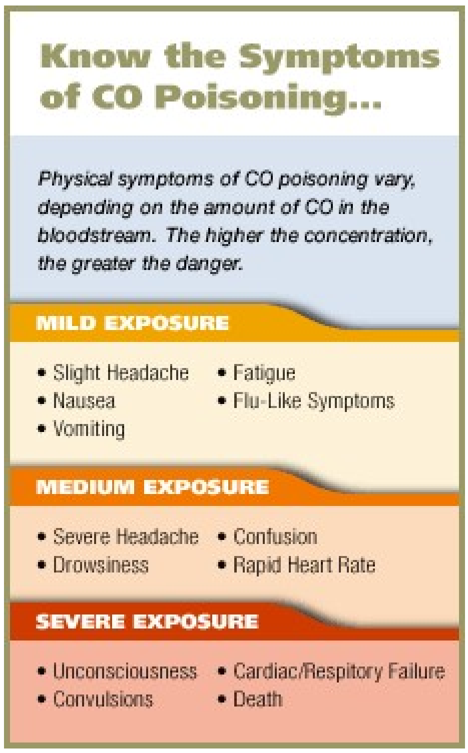


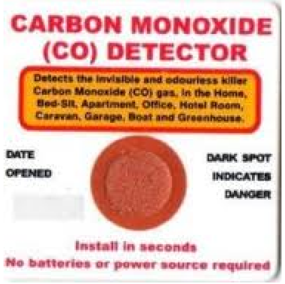
Table 2 Symptoms of CO poisoning

1600 ppm of CO (0.16%) will kill you in less than 2 hours – 6,400 ppm (0.64%) wil keil you in less than 20 minutes. Poisoning happens slowly and imperceptively and can easily be mistaken for other things. The symptoms will disappear if you leave a contaminated room and this is one indicator that it is CO poisoning not flu. The process is reversible, if caught in time, as the formation of HbCO can. be reversed by breathing excess oxygen. Severe poisoning is sometimes treated in a hyperbaric (high pressure) oxygen chamber. This a good example of Le Chatelier's principle in action.

Suicide or murder using car exhaust gases used to be quite common as the exhaust gases used to contain high levels of CO (~7,000 ppm), enough to cause quite rapid death. However, catalytic convertors remove CO and convert it into CO_2 (along with nitrogen oxides and unburnt hydrocarbons). All modern cars have catalytic convertors and so this form of suicide is no longer efficient – suffocation takes much longer than CO poisoning.

CO poisoning can be prevented by adequate ventilation and well-maintained boilers. The CO levels around well-maintained a gas cooker are low (5-15 ppm). It is also important to make sure that chimneys or flues are not cracked or blocked. Cigarettes produce carbon monoxide so smokers have higher levels of CO in their blood than non-smokers. This is one factor linked to heart problems in smokers, as CO reduces the oxygen-carrying capacity of haemoglobin. For more information see:
http://www.healthline.com/blogs/smoking_cessation/2008/08/carbon-monoxide-in-cigarette-smoke.html

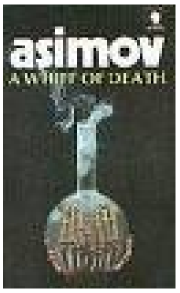
But how do you know if you're being poisoned? Most houses now have smoke detectors to warn of fire and it is also recommended that people install CO detectors. A simple, cheap version has a small patch containing chemicals that change colour (beige to black) if high levels of CO are present.



These have a limited lifetime (a few months) and are not very sensitive and several types of battery or mains operated CO detectors are available, with three different operating mechanisms. One is based on a colour change measured photometrically (known as biomimetic sensors); another type uses an electronchemical cell; the third type uses a tin dioxide semiconductor whose resistance changes if CO is present. They are more expensive (€30-60) but provide an early warning of high CO levels. You can find out how they work at:

How Stuff Works
http://home.howstuffworks.com/home-improvement/household-safety/tips/carbon-monoxide-detector.htm

About Chemistry
http://chemistry.about.com/b/2010/11/28/how-carbon-monoxide-detectors-work-2.htm



I have come across at least one murder mystery that features deliberate CO poisoning – *The Whiff of Death* by Isaac Asimov. Asimov got the chemistry right as he was a biochemist by training and wrote non-fiction science books as well as science fiction.

CO detectors are made in Shannon, Co. Clare by EI Electronics based on electrochemical technology. www.eielectronics.com/ and you can buy them in hardware stores. **Better to be CO safe than sorry.**

For an Irish information site on the dangers of CO see: http://www.carbonmonoxide.ie/

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(Contd. From p. 45)

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Marie Ryan is a 4th science education student at the University of Limerick and this article is based on her experiences and end-of-week reflections on her 4th year teaching practice in Autumn 2010.

Diary

2011

ASE, N. Ireland Conference
STEM - Sharing Good Practice
March 11
Belfast, N. Ireland
http://www.ase.org.uk/ase-regions/northern-ireland/events/2011/03/11/241/

ISTA Annual Conference
8-10 April
Thurles
www.ista.ie

IOSTE - NW Europe
Contemporary Issues in Science and Technology Education
Mini-symposium June 20-21
http://ioste-nwe.wikispaces.com/
Reading, UK

July 24-28, 2011

ChemEd 2011
July 24-28
Western Michigan University, Kalamazoo, USA
http://www.wmich.edu/chemed/

Eurovariety in Chemistry Education (EiCE)
September 1-4
Bremen, Germany
http://www.uni-kassel.de/hrz/db4/extern/Eurovariety/index.php?SID=50eae5481675719a8f14b97717cb4f1a&action=cms&id=74

Variety in Chemistry Education (ViCE)
September 1-2
York, UK
www.heacademy.ac.uk/physsci/events/detail/2011/vice_2011

9th. ESERA
September 5- 9
Lyon, FRANCE
http://www.esera2011.fr/

30th. ChemEd-Ireland
October 22
UCC, Cork
d.kennedy@ucc.ie

2012

22nd ICCE/11th. ECRICE
Stimulating Reflection and Catalysing Change in Chemistry Education
July 15-20
Rome, Italy
www.22icce.org/home.html

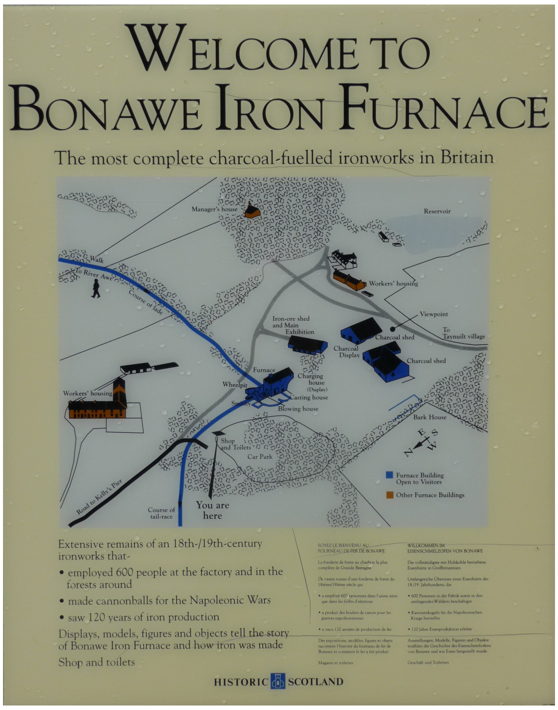
Places to Visit: Bonawe, Loch Etive, Argyll, Scotland – a charcoal-fired Iron Works

The iron furnace (see also front cover)

On the shores of Loch Etive, at the head of Glencoe, can be found the remains of a charcoal-fired iron furnace, opened in 1753. Its isolated location in Western Scotland has meant that the remains are in an excellent state of preservation and it was in use until 1876. It was built by an ironmaster from Cumbria to make use of the extensive forests of Argyll and the abundant water supplies – the iron ore was imported by sea from Cumbria and pig iron was exported in the same way from a pier on the Loch.

The site is extensive with many buildings scattered over the site as shown in the plan below. The site is run by Historic Scotland (see http://www.historic-scotland.gov.uk/index/places/propertyresults/propertyoverview.htm?PropID=PL_036&PropName=Bonawe%20Historic%20Iron%20Furnace).

At its peak it produced 700 tons of pig iron a year and employed 600 people, many of them charcoal burners. The site has a display describing the process of making iron and the history of the iron works.



Bonawe is the most complete charcoal-fired ironworks in Britain. The entire manufacturing process can be traced on the site:

- The lade – bringing water from the River Awe onto the waterwheel to power the bellows;
- The two vast charcoal sheds – where enormous quantities of fuel were stored in dry conditions;
- The small charcoal shed - where imported high-quality haematite ore was stored, along with the limestone (for removing impurities during smelting);
- The charging house – where the raw materials were weighed and carefully loaded into the furnace mouth;
- The furnace, blowing-house and casting-house – where the iron ore was smelted by cold blast into pig iron;
- Bonawe House – built for the manager (please note this private house is *not* open to visitors);

- The two blocks of housing – where the workers and their families lived;
- Kelly's Pier – where most of the raw materials were landed, and where all the finished products (mostly pig iron) were loaded onto vessels

(This description of the site is taken from the Historic Scotland website.)

Some of the storage buildings on the site – the massive sheds were used to store charcoal

The peaceful site is surrounded by woods and mountains and overlooks Loch Etive

Smelting iron ore using charcoal was superseded by the use of coke (from coal) which was pioneered by Abraham Darby of Coalbrookdale in 1709 (another key place to visit.)

So Bonawe was technically obsolete even when it was first built but it survived due to the availability of wood for charcoal and many manufacturers continued to prefer iron made with charcoal.

Location
The site is just off the A85 near the village of Tayuil in Argyll.
Address:
Bonawe, Tayuilt
Argyll PA35 1JQ
Scotland

Opening arrangements: Summer
1 April - 30 September, Mon Tue Wed Thu Fri Sat Sun, 9.30 am to 5.30 pm
Closed during winter season

Admission prices: Summer
Adult £4.20, Child £2.50, Concession £3.40

More information:
The Royal Commission on the Ancient and Historical Monuments of Scotland has details of site with many photos and drawings, plus references to articles and books.
http://canmore.rcahms.gov.uk/en/site/23523/details/bonawe+ironworks+lorn+furnace/

Note: I visited Bonawe in June 2009 and if you are touring this part of Western Scotland I recommend a visit.
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