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.

Cover design: Tony Hartnett, Shoreline Graphics, Ballyvaughan, Co. Clare tony@shoreline.ie

Cover photo: The participants at Eurovariety 2013 enjoying the evening sun at Killaloe. (Photo: P.E. Childs)

Editor: Peter E. Childs Assistant editors: Marie Walsh, Maria Sheehan, Sarah Hayes, Anne O'Dwyer

Editorial

Introduction

Apologies for the late arrival of this issue – Spring is late again, partly due to the difficulty in getting papers from last year's ChemEd-Ireland conference. The Spring issue has for many years been devoted the Proceedings of the previous ChemEd-Ireland conference. The other reason was I was caught up in the organisation and running of Eurovariety 2013, an international conference held at the University of Limerick in July for third-level chemistry lecturers, mainly from Europe (see report on p.51).

The conference is sponsored by the EuCheMS Division of Chemical Education, and the Division held their annual meeting in Limerick after the conference. I produce an annual report on chemical education in the Republic of Ireland, and I reprint the summary of this year's report below, as I think it will be of interest to readers.

Summary:

Education in Ireland is in a state of rapid change, despite economic restrictions, due an energetic and reforming Minister of Education. Several initiatives announced this year have implications for chemical/science education.

a) A major restructuring of the Junior Certificate (age 12-15) is underway with the changes starting to come into effect in 2013. Three subjects are compulsory (English, Mathematics and Irish) with 240 hours teaching time and schools may choose between 6-8 other subjects (200 hours a reduction in time), which includes Science (a single, combined subject). There is also an option for schools to offer and even create up to four short courses (100 hours). Science is not compulsory and students will do less science. There will be less emphasis on a terminal examination and more continuous assessment. (http://ncca.ie/framework/doc/NCCA-Junior-Cycle.pdf)

b) A major revision of the Leaving Certificate (age 15-17) Science subjects (Biology, Chemistry and Physics) is also underway. New syllabi have been produced, sent out for consultation and revised. A major change is the inclusion of practical assessment for the first time, examined in schools through a practical examination. There are also proposals to revise the style and structure of the examination papers to encourage more creativity, critical thinking and understanding rather than rote learning and regurgitation of answers to standard questions. (http://www.ncca.ie/en/Publications/Reports/Senior_Cycle_Science_Report_on_the_consultation_.pdf)

c) A major shake-up of third level has also been announced: some Institutes of Technology will merge to form technological universities; teacher education providers will merge their activities into a smaller number of centres; higher education institutions will form regional clusters to encourage cooperation and sharing of resources. (http://www.hea.ie/content/new-landscape-higher-education)

d) Teacher education providers will merge their activities into a smaller number of regional centres, based on the recommendations of an International Review Panel. (http://www.education.ie/en/Press-Events/Press-Releases/2012-Press-Releases/Report-of-the-International-Review-Panel-on-the-Structure-of-Initial-Teacher-Education-Provision-in-Ireland.pdf)

e) The length of the Postgraduate Diploma in Education (the major route to producing second level science teachers by the consecutive model) has been increased from one year to two years from September 2013. The Teaching Council is proposing to changer the registration requirements for second-level teachers to strengthen their subject knowledge, and this has implications for those institutions producing teachers, as it may mean restructuring courses. (http://www.teachingcouncil.ie/teacher-education/initial-teacher-education-ite.191.html)

f) Enrolments in chemistry at second level and at third level continue to increase, with a greater demand for all science courses at third level.

Thanks to Tony Hartnett who has been designing the covers of *Chemistry in Action!* for many year but is now emigrating,

Peter E. Childs
Hon. Editor

Education News and Views

The Editor welcomes contributions and news of interest to chemistry teachers in this section.

First graduating class

The first students from the BSc in Science Education at NUI Maynooth graduated in September 2012. This means there are now five concurrent programmes producing science teachers in the Republic (UL, DCU, UCC, NUIM and soon UCD).

First Class of BSc Science Education students graduate – September 2012

Graduating Class with Professor Bernard Mahon, Dean of Science & Engineering, Professor James A. Walsh, Deputy President and Vice-President for Innovation, Dr. Aidan Mulkeen, Head of Education Department, Ms. Majella Dempsey, Course Leader and Dr. Gerry Jeffers. Sarah Abbott, Jacqueline Boyd, Claire Brennan, Killian Carr, Christine Cassells, Ciaran Cassidy, Fionnuala Cleary, Niamh Convey, Joann Dempsey, Garrett Dooley, Mark Gordon, Karen Judge, Charlene Kehoe, Andrew Little , Marc Lynn, Ciara McCabe, Rebecca McEvoy, Shauna McGee, John Monaghan, Zoey Quinn, Deidre Roddy and Ciara Sheehan.

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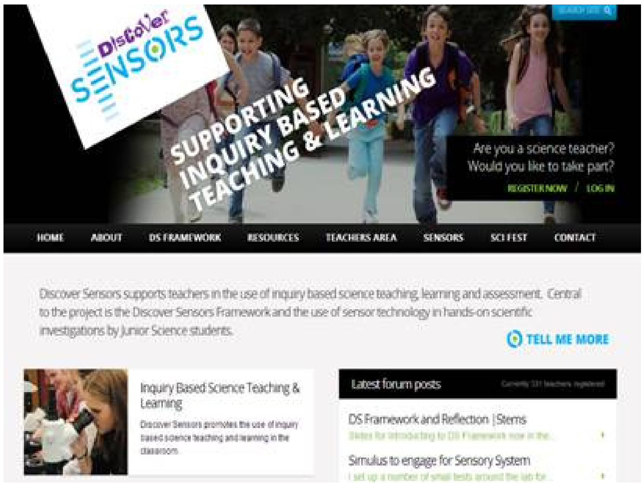
BSc Science Education students at NUIM embark on an exciting initiative with Discover Sensors

The Discover Sensors initiative promotes inquiry based science teaching and learning (IBST&L) to Junior Certificate science teachers. It offers a blended approach of Continued Professional Development (CPD) and is supported by a website (***www.discoversensors.ie***) which houses a multitude of Junior Certificate science teaching resources. All of these resources have been made available to the BScEd students in NUI Maynooth.



Discover Sensors is delighted to partner with NUI Maynooth Science Education Department in sharing all of the project resources with the BScEd course. Discover Sensors will work with the BScEd students, their Placement Tutors, Methodology Lecturers and Course Leader to share and develop the pedagogical approach.

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Personnel changes in science education

Dr Philip Mathews has retired from TCD, where he was the science education lecturer in the School of Education. Philip was well known to a generation of science teachers and gave several talks at ChemEd-Ireland Conferences. He has been replaced by Dr Colette Murphy, formerly of Queen's University, Belfast, who is also Director of Research in the School of Education. We wish Colette well as she takes over from Philip.

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Dr Orla Kelly is a graduate of DCU and has a PhD in science education. Sheworked for several years in Plymouth in Primary STEM education and has moved back to Ireland this year to the Church of Ireland College of Education in Rathmines. She is a co-organiser of the 2013 NW-IOSTE Science Education Symposium (see below).

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NW-IOSTE Mini-Symposium

'Science Education Research'

25-26th October 2013

Church of Ireland College of Education, Rathmines, Dublin

The mini-symposium will look to take the broad theme of research in science education and is open to all those who may wish to present completed or on-going research projects (postgraduate or post-doctoral) that involve science teaching and/or science education. Research areas may be either practice based or theoretical discussions.

The main aim of the symposium is to bring researchers and practitioners from across the Western European region together to discuss and help develop our own research projects and interests and to explore the possibility of collaborative developments, particularly in light of the **European Union Horizon 2020 Research and Innovation Framework.**

It is hoped that the symposium will be useful for practitioners and researchers at every stage of their career, but those new to research, or who are in the process of developing ideas are particularly welcome.

For information and submissions contact:
rcutting@plymouth.ac.uk
(for registration, paper submissions or other conference matters);
okelly@cice.ie
(for accommodation, travel or local information for Dublin)

The previous NW-IOSTE Mini-Symposium in Science Education was held at the University of Limerick in April 2012.

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ChemEd-Ireland returns to Limerick

The ChemEd-Ireland conferences, which were started by Dr Peter Childs in 1982, now rotate around a number of third level centres. Last year's was in Dublin City University and the 2013 conference will be in Limerick Institute of Technology on Saturday 19th October. The organiser is Marie Walsh (marie.walsh@lit.ie) and an application form is included in this issue. The 2014 conference is scheduled for Dublin Institute of Technology. The conference now alternates between the east coast and west coast and is held on the Saturday in October prior to the Bank Holiday weekend and half-term.

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7th Chemistry Demonstration Workshop

The annual 4 day residential workshop was held in the University of Limerick from 24-28th June 2013. The aim of the workshop is to make chemistry teachers and trainne science teachers more confident in doing chemistry demonstrations in the classroom; to increase their repertoire of demonstrations; to help them prepare and give a science magic show. The attendees are a mix of science teachers and newly qualified science education students. The course is subsidised by grants from PDST and Pharmachemical Ireland. A report on this year's course is on p.53 Everyone who has attended these workshops in the past 7 years has found them very beneficial and a boost to their teaching. If you are interested in coming on the workshop in 2014 contact peter.childs@ul.ie for details.

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Eurovariety 2013

The 5th European Variety in Chemistry Education conference (Eurovariety) was held in Limerick 3-5th July 2013. It was attended by over 80 people from around Europe and as far as Canada and the USA. The conference is aimed at third level chemistry lecturers, but rather than being concerned with some specific research topic in chemistry, it is concerned with the teaching and learning of chemistry. See p.51 for a report.

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Assessment of practical work in the revised LC Chemistry syllabus

Eureka!
Eureka Centre
for Inquiry Based Education
in Science and Mathematics

A **one-day course** for Chemistry Teachers was held in the **Eureka Centre UCC** on the assessment of practical work in the revised Leaving Certificate Chemistry syllabus.

This Summer School for Chemistry Teachers was first run last year in 2012 and was so popular with teachers that it was repeated on a second day. In view of this fact the session will take place on Tuesday 2nd July and Wednesday 3rd July. Due to the emphasis on laboratory practical work, the

number of teachers attending each day will be limited to 24. The course is sponsored by PDST and BASF.
http://www.ista.ie/news/assessment-practical-work-revised-leaving-certificate-chemistry-syllabus

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Chemistry courses for non-specialist teachers

Two courses were run this summer in chemistry for non-specialist teachers i.e. science teachers who are teaching chemistry but don't have a formal qualification in chemistry. The courses are sponsored by the Royal Society of Chemistry through the Education Division's Ireland Region committee. One course was held in Dublin at Blackrock College (19-20 June) and the other in Limerick at Ard Scoil Ris CBS (25-26 June).
http://www.rsc.org/education/cpd/chemnonspec/index.asp

These courses are a great initiative and should improve the teaching of chemistry, particularly in the junior cycle, where the majority of teachers are biologists.

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ISTA 51st Annual Conference 2013

12-14th April, Gorey, Co. Wexford

The annual ISTA Conference was held in Gorey Community School. Gorey. The programme of events included some world renowned speakers such as the astrophysicist and discover of pulsars, Dame Jocelyn Bell Burnell, who was recently inaugurated as Pro-Chancellor of Trinity College and voted in the top five of Great British Innovators. She gave a plenary talk entitled 'We are made of star stuff'.

Prof Ian Robertson, author, Chair of Psychology and Director of Institute of Neuroscience at Trinity College, opened the Conference at the Ashdown Park Hotel with a talk entitled 'The Winner Effect: the neuroscience of success and failure'.

Dr Tony Scott, cofounder of BT Young Scientist and Technology Exhibition and People of the Year Award winner 2012, was the guest of honour at the gala opening on Friday.

The very popular Dr Aoife McLysaght, Geneticist, talked about 'The Adaptive Ape', and Alom Shaha, author of *The Young Atheist Handbook*, discussed 'Science and Religion in the Classroom', while Dr Paul McCrory gave a plenary demonstration.

An extensive range of workshops ran in Biology, Physics, Chemistry and Junior Science, as well as in Computational Science, iPad Applications, KidWind and drop in sessions on Enquiry based learning.

The Annual Awards will be announced at the Conference Dinner in Ashdown Park Hotel on the Saturday night.

Next year's conference is in NUI Galway from 11-13th April 2014. You should make an effort to attend and if you aren't already, become a member of the ISTA.
www.ista.ie

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Teaching Council requirements for teaching chemistry

Chemistry

Applicants must provide officially certified evidence of satisfactory achievement in primary degree studies (or equivalent) as outlined hereunder:

- The study of Chemistry as a major subject in the degree extending over at least three years and of the order of 30% at a minimum of that period.
- Details of the degree course content to show that the knowledge and understanding required to teach Chemistry to the highest level in post-primary education has been acquired.
- Details of degree course content where the studies involved modular or applied subject content or where studies were in a related subject area will require specific assessment to determine equivalence.
- Details of course and practical work content completed during the degree programme together with teaching/tutorial times, list of experiments and practicals.
- Explicit details of standards achieved in degree studies in Chemistry with at least an overall Pass result in the examinations in Chemistry

Recognition to teach Chemistry also confers recognition to teach Science in the Junior Certificate programme.

Additional information (i) where greater clarity is requested or (ii) which would otherwise more fully support the application must be provided as required.
http://www.teachingcouncil.ie/

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Science Communication For All

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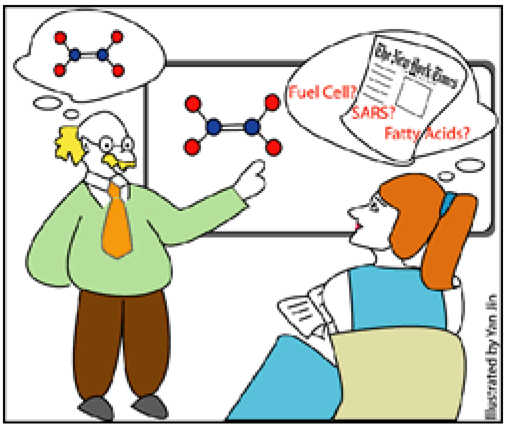
First published in *Chemistry International* Vol. 25 No. 5 September-October 2003
Available at: http://www.iupac.org/publications/ci/2003/2505/1_glaser.html

The IUPAC Committee on Chemistry Education is concerned with good practice in chemical education at all levels and the public appreciation of chemistry. The Committee believes that the following article is a helpful contribution to these subjects. The views are the author's own and are not a part of IUPAC's strategy.

In his Rede Lecture on *The Two Cultures* in 1959, Charles Percy Snow argued that "persons educated with the greatest intensity we know can no longer communicate with each other on the plane of their major intellectual concern" and he concluded that this is "serious for our creative, intellectual, and, above all, our normal lives. It is leading us to interpret the past wrongly, to misjudge the present, and to deny our hopes of the future. It is making it difficult or impossible for us to take good action." In the following decades science progressed with political and public support. Yet, the gap between scientific and humanistic cultures grew larger and societal resistance to real and perceived adverse consequences of science grew from grass-roots activism to well-organized movements. Current concerns about science are exemplified in a conference that The Center for Science in the Public Interest hosts this summer in Washington, D.C., on "Conflicted Science: Corporate Influence on Scientific Research and Science-Based Poli cy."



Fear of science is not a recent phenomenon and it is normal in the sense that humans approach everything new with some apprehension. What is new, however, is that scientists now also are worried. Martin Rees, the United Kingdom's Royal Astronomer, warns in his book *Our Final Hour* how terror, error, and environmental disaster threaten humankind's future. Such concerns were also expressed at the National Organic Symposium of the American Chemical Societyóheld in Bloomington, Indianaóthat I attended and where I wrote this essay. On 10 June 2003, Peter Schultz of the Scripps Research Institute presented a compelling lecture on the synergistic use of biology and chemistry to make "organisms with expanded genetic codes." The natural amino acids and the DNA bases no longer are enough; organisms can now be "synthesized" containing say 25 customized amino acids or more than the usual 2 base pairs. The first question after the talk was about possible biohazards of this research. Had Rees known about this research, he surely would have added a chapter to his book.

The Need for Engaging the Public in Science Communication

Stewart Brand, cofounder of the Global Business Network, boldly states that "Science is the only News . . . human nature doesn't change much; but science does, and the change accrues, altering the world irreversibly." Science is pervasive in all aspects of modern society and Brand's statement captures the crucial fact that science is growing at an incredible speed. Much of the science important for a person's life in the 21st century will be discovered *after the person has left formal education*. The preparation of students for life-long learning has to become more than a catch phrase, it has to become the highest goal. From this insight derives the mandate to promote science communication in society.

"the press will possibly play the central role in how scientifically driven transitions are approached and handled in the future."

The traditional intelligentsia utterly failed to recognize this essential need and, instead, have propagated postmodernist myths about science, which were so wonderfully exposed by Paul Gross and Norman Levitt in their book *Higher Superstition*. In his book *The Third Culture* John Brockman calls for creating a culture to replace traditional intellectuals and to communicate science and science-based philosophy. Brockman explains in his book and at edge.org that "the third culture consists of those scientists and other thinkers in the empirical world who, through their work and expository writing, are taking the place of the traditional intellectual in rendering visible the deeper meanings of our lives, redefining who and what we are."

In his editorial "Public Engagement with Science" that appeared in *Science* (14 February 2003), Alan Leshner wrote that "we need to engage the public in a more open and honest, bi-directional dialogue about science, technology, and their products, including not only their benefits but also their limits, perils, and pitfalls. *We need to respect the public's perspective and concerns, even when we do not fully share them* (emphasis ours), and we need to develop a partnership that can respond to them." To do so requires informed engagement by the public and, as Bill Moyers pointed out in his article on "Journalism and Democracy" in *The Nation* (7 May 2001), "the press will possibly play the central role in how scientifically driven transitions are approached and handled in the future." Are the media ready to meet this challenge? Is the public ready to engage in science communication? The second question probably is the critical one since the media respond to public demands. To prepare the public for responsible and bi-directional science communication presents a formidable pedagogical challenge for modern college education. Can it be met?

The State of Undergraduate Science Education

U.S. Census data show that in the last 35 years the number of college age (18-24) Americans remained roughly the same, about 26 million. In the same time, the number of college students in that age group has increased steadily from about 6 million in 1970 to about 9 million in 2000; a 50 percent increase. Data compiled by the Committee for Professional Training of the American Chemical Society show that during the same time period the numbers of M.S. and Ph.D. degrees awarded has remained essentially the same, about 2000 degrees of each type every year. The number of B.S. degrees fluctuated significantly; first climbing quickly from about 8000 in 1970 to over 10 000 in 1980, then declining to less than 8000 in 1990. In the last decade the numbers have gone up again to well above 11 000. Chemistry as a major did not gain from the added numbers of college students, but instead barely held its ground.

The CIITN project involves teaching chemistry to science majors in the context of real-world issues . . .

Despite the static interest in chemistry, the audience for U.S. college chemistry education has changed dramatically. This is because the share of young people entering college went up from 20 percent in 1970 to about 35 percent today. This is a positive trend and broader access to education for larger segments of society is desirable. The proportion of those required to take chemistry has remained the same and, consequently, chemistry instruction has become even more of a challenge for students *and* for faculty.

One of my recently retired colleagues, after perfecting his style over 35 years of enthusiastic teaching at the University of Missouri (MU), said on various occasions that he "cannot make it any easier any more." A number of factors have contributed to a gradual erosion of educational standards in college science teaching: more students in larger classes, who represent almost twice the percentage of that age group compared to two generations ago; students arriving less prepared from high school; and students exposed to a postmodernist academic climate. Simplified textbooks, algorithmic testing of isolated and simple items, norm-based grading, and the pressure toward grade inflation have camouflaged this process.

There is a dilemma here that needs to be confronted, and soon. The problem cannot be solved via content simplification and traditional pedagogical strategies. Reality is complex rather than simple. There is the chemistry of the combustion of fossil fuels, it is simple and it should be taught rigorously. The complexity of the topic emerges in addressing environmental, economic, and political consequences of societal energy needs. The chemistry of pesticides is slightly more involved and it should be taught in detail. The complexity of this and other health-related topics emerges in discussions about what exposure levels are considered safe for humans and the decision- making process in establishing such levels. The chemistry of sugars, proteins, and fats is somewhat demanding, but it is necessary to understand the complexities of dietetics. If chemists will again dare to teach their science in its full complexity, students will appreciate the efforts and society will take a gigantic step toward science communication for all!

"Chemistry is in the News" Rises to the challenge

Students need to learn to recognize and to construct these connections. They have to be prepared to evaluate evidence, to appreciate quantitative data, and to understand what they mean. Students need to be able to locate additional data on their own, and then, finally, to make judgments that are sound on many levels: economic, political, philosophical, ethical, and moral. Just 10 years ago, any attempt at implementing systemic change to meet such ambitious goals would have failed for lack of access to media and information and because of problems with course organization, management, and communication. But these barriers no longer exist! Most universities provide phenomenal online access to information for all students and support for course management and communication tools. The combination of this infrastructure with pedagogical strategies that eschew zero-sum outcomes provide extraordinary opportunities. The Chemistry is in the News (CIITN) project at the University of Missouri-Columbia capitalizes on these opportunities and prepares young citizens to comprehend and actively engage in science communication.

The CIITN project involves teaching chemistry to science majors in the context of real-world issues and helping students connect real-world social, economic, and political issues to the teaching of chemistry. CIITN activities include the study, creation, and peer review of online projects based on actual news articles from the popular press.

Because the CIITN project relies on online media, a taxonomy was established of news-media-based learning activities to provide a conceptual framework for their description (see table). Ideally, one wants to engage students in a full range of cognitive skills. The various levels of the CIITN project meet this challenge. The implementation and integration of Level-1 to Level-5 of CIITN activities has been accomplished. Students working in small groups were exposed to news items that consisted of an actual recent newspaper article, editorial comment, and questions. The students studied 10 to 12 instructor- created news items, created one news item, and reviewed a number of student-created news items.

These CIITN activities served several purposes. First, the activities made connections between organic chemistry and societal issues and explicit problems therein, and they required students to think critically about these connections. This provided an authentic learning task in which students were actively engaged with the course content. Second, the activities increased communication and interaction among students and between students and the instructor, making a large lecture course seem less impersonal. Third, the activities helped develop skills central to scientific inquiry (data mining) and valuable for students' educational and career goals (e.g., collaboration, communication, and research). Overall, the CIITN activities create a more effective learning environment within a large lecture course and in doing so they promote students' learning of chemistry.

Taxonomy of News-Media-Based Learning Activities

<table>
<tr><th>Level</th><th>Activity</th><th>Quality Review</th><th>Resource</th><th>Outcome</th></tr>
<tr><td>1</td><td>Read News Article</td><td>None</td><td>Online news media</td><td rowspan="6">Knowledge Comprehen sion Application Analysis Synthesis Evaluation</td></tr>
<tr><td>2</td><td>Read News Items Editorial & questions</td><td>Instructor Review</td><td rowspan="5">Online Database & Software Tools</td></tr>
<tr><td>3</td><td>Read & Create News Items</td><td>Instructor Review</td></tr>
<tr><td>4</td><td>Read & Create & Judge News Items</td><td>Internal Peer Review</td></tr>
<tr><td>5</td><td>Read & Create & Judge News Items</td><td>External Peer Review</td></tr>
<tr><td>6</td><td>Read & Create & Judge News Items</td><td>Internatio nal Peer Review</td></tr>
</table>

Level-5 involves an external peer-review process in which students taking similar courses at different universities review each other's projects. Aside from the additional management effort, Level-4 and Level-5 activities differ significantly: the evaluators no longer know the evaluees, both have been instructed in different places in slightly different ways, and, most of all, their backgrounds and experiences may be greatly different. Indeed, the students would benefit the most if some of the views held by the different groups were in conflict. External peer review contributes to the development of the students' ability to present their own positions and hear, understand, and respect other points of view. Hence, through Level-5 activities students develop an appreciation of diversity and learn what it means to be a "good citizen." In collaboration with Dr. Susan Schelble, Level-5 CIITN activities involving inter-state collaborations between student groups in Missouri and Colorado were implemented in the winter semesters of 2002 and 2003.

Level-6, which has not been implemented yet, involves border-crossing peer review, a powerful strategy for adding a global dimension to newsmedia- based learning activities. In this level, peerreview results would be incorporated into the course grade and the students would need to be aware of the international perspective of their projects. The ultimate challenge of this level is the requirement of international collaboration in the preparation of the group projects. Level-6 activities present an opportunity to help students to become "good global citizens. " The importance of this opportunity is highlighted in Thomas Friedman's column, published 1 June 2003 in the *New York Times*, in which he explains why so many people are upset with America. His thesis: "America has begun to touch other people's lives more than their own governments do and therefore people all over the world want to be able to vote on American power." Modern Americans need to understand this aspect of being global citizens.

In a letter to Edward Carrington, Thomas Jefferson wrote in 1787, "The basis of our governments being the opinion of the people, the very first object should be to keep that right; and were it left to me to decide whether we should have a government without newspapers or newspapers without a government, I should not hesitate a moment to prefer the latter. *But I should mean that every man should receive those papers and be capable of reading them* (emphasis ours)." The informed citizen is essential to democracy and, today, Jefferson's mandate requires scientific literacy. The political goal therefore has to be science communication for all and the most promising strategy would involve instruction in science communication for students in their early years of undergraduate college education.

CIITN has been funded by the University of Missouri System, the University of Missouri-Columbia, *The New York Times*, and The Camille and Henry Dreyfus Foundation. It is currently funded by the Department of Undergraduate Education of the U.S. National Science Foundation. The CIITN team includes Dr. Rainer Glaser, professor in Chemistry at MU; Dr. James Groccia, director of the Program for Excellence in Teaching at MU; Dr. Susan Schelble, professor in Chemistry at the University of Colorado-Denver; and a group of graduate students Martin Wu, John Sui, Kathleen Carson, and Brian Hodgen at MU and Eric Lupo at UCDóthat brings exceptional interdisciplinary breadth of talents and perspectives to the instructional design and the assessment of the project. This team is dedicated to affecting a systemic change in college science education in the years to come and we are seeking international collaborators with a shared vision and interest to play constructive roles. We invite interested parties to contact us.

Dr. Rainer Glaser <glaserr@missouri.edu>, is a professor in the Department of Chemistry at the University of Missouri-Columbia.
www.missouri.edu/~chemrg
http://ciitn.missouri.edu

Dr Glaser was one of the plenary speakers at Eurovariety 2013, University of Limerick, 3-5 July 2013.

□

The latest form of the Periodic Table (see p. 21 for the latest elements)

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Nanotechnology Experiments for General Chemistry Laboratory Classes

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Nanotechnology has been an area of both research and development and scientific speculation, from devices and toys utilizing liquid crystals to carbon nanotubes to nanomachines to nanodrug delivery systems to a proposed space elevator. Nanotechnology is part of our daily lives, but we are not always aware of their applications. In chemical education, nanotechnology is only now being introduced into textbooks for general chemistry with almost no inclusion in the student laboratory. Laboratory procedures and kits have been developed at the Materials Research Science and Engineering Center (MRSEC) at the University of Wisconsin-Madison http://mrsec.wisc.edu/Edetc/index.html with a video lab manual showing procedures in Quicktime movies.[1]

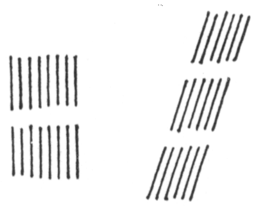
This author has utilized several low-cost nanotechnology experiments, and some related demonstrations, into the non-major and general chemistry laboratory that were modified from procedures and kits developed at the MRSEC. These experiments include liquid crystals, aqueous ferrofluid, Nitinol metal memory wire, and a microcrystalline titanium dioxide solar cell. Discussions of applications of these experiments are included in the classroom and laboratory. Students, even the non-science majors, gain an understanding of nanotechnology and how it affects them in their daily lives.

In this article, I will focus on liquid crystals

Liquid crystals are organic compounds that are in a state between liquid and solid forms. They are viscous, jelly-like materials that resemble liquids in certain respects (viscosity) and crystals in other properties (light - scattering and reflection). Liquid crystals must be geometrically highly anisotropic (having different optical properties in different directions)-usually long and narrow - and revert to an isotropic liquid (same optical properties in all directions) through thermal action (heat) or by the influence of a solvent.

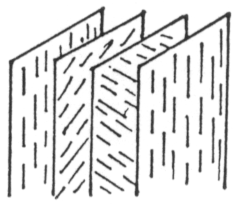
Liquid crystals are classified as:

smectic: molecules arranged in horizontal layers or strata and are standing on end either vertically or at a tilt.



nematic: molecules possess a high degree of long-range order with their long axes approximately parallel, but without the distinct layers of the smectic crystals.

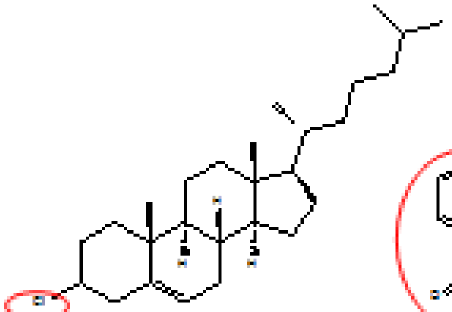
lyotropic: molecules consist of a nonpolar hydrocarbon chain with a polar head group. In a solvent, such as water, the water molecules are sandwiched between the polar heads of adjacent layers while the hydrocarbon tails lie in a nonpolar environment.



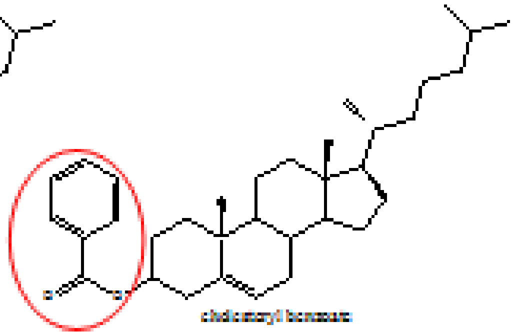
If smectic and nematic liquid crystals are subjected to changes in temperature, they change their form and their light transmission properties splitting a beam of ordinary light into two polarized components to produce the phenomenon of double refraction. This results in the appearance of the characteristic iridescent colours of these types of liquid crystals. This type of liquid crystal finds use in thermometers, egg timers, and other heat sensing devices. Changes in structure can also be accomplished using a magnetic field which make them useful in calculator or other LCD displays. Temperature sensitive liquid crystals were used in Mood Rings.

When lyotropic liquid crystals are subjected to disturbances, such as stirring or squeezing, the layers of crystals are disturbed altering their light transmission characteristics to produce colour changes similar to the smectic and nematic liquid crystals described above. These are the type of liquid crystals used in the “Press Me” stickers.

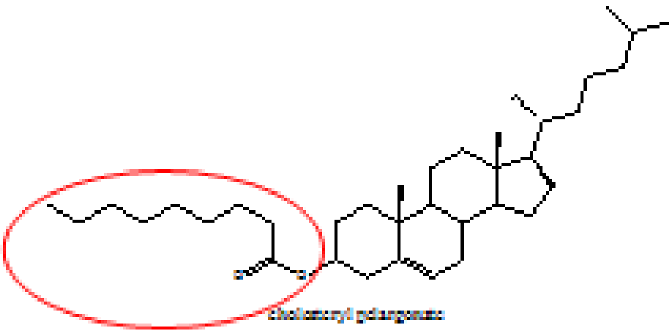
Common liquid crystals are composed of derivatives of cholesterol, $C_{27}H_{46}O$. Some common liquid crystal materials are cholesteryl chloride, $C_{27}H_{45}Cl$, cholesteryl benzoate, $C_{34}H_{50}O_2$, cholesteryl pelargonate, $C_{36}H_{62}O_2$, (also called cholesteryl nonanoate), and cholesteryl oleyl carbonate, $C_{46}H_{80}O_3$.



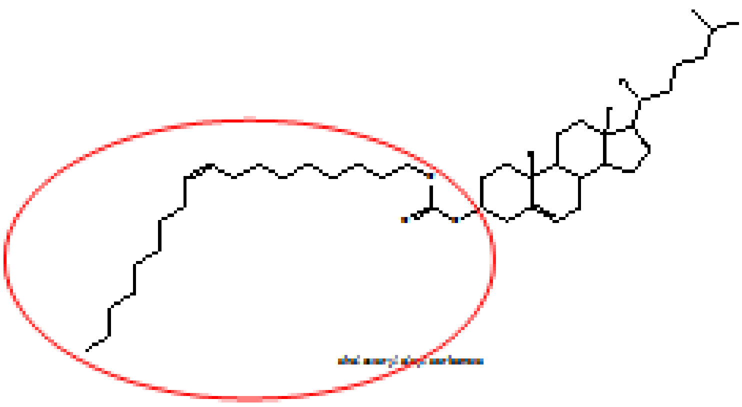
cholesteryl chloride



cholesteryl benzoate



cholesteryl pelargonate



These cholesteric-nematic liquid crystals reversibly change colour as the temperature changes. One of the principal advantages of liquid crystals is their ability to map out thermal regions of different temperature. Liquid crystal films exposed to the atmosphere will decompose slowly; their lifetime can be extended by encapsulation.

Materials Needed:

cholesteryl chloride
cholesteryl benzoate
cholesteryl pelargonate (also called cholesteryl nonanoate)
cholesteryl oleyl carbonate
applicator sticks or thin wood splints
black plastic squares (use a heavy plastic trash bag) about 2 cm x 2 cm
Clear, colourless plastic shipping tape, 5 cm (2 inches) wide
scissors
Glass vials
Funnels, to fit glass vials
Heat gun (a small hair blow dryer can be used)
Thermometer, 120°C

Safety Precautions:

Wear approved eye protection at all times in the laboratory.

Cholesteryl liquid crystal materials may cause irritations to skin or eyes. In the event of contact, rinse well with fresh water..

Disposal

Dispose of all materials in the proper waste containers.

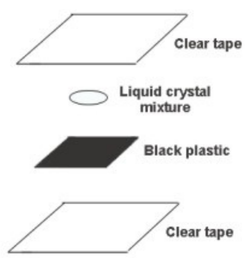
Preparing a pressure sensitive liquid crystal mixture

To prepare a pressure sensitive liquid crystal mixture, place 0.38 g cholesteryl oleyl carbonate, 0.38 g cholesteryl pelargonate, and 0.25 g cholesteryl chloride in a small glass vial. Melt the solid in the sample vial using a heat gun. Allow the mixture to cool to room temperature.

To make a liquid crystal display, use a wood applicator stick to place a small amount of the liquid crystal mixture on a piece of black plastic about 2 cm square. Encapsulate the liquid crystal mixture and black plastic between two pieces of clear plastic shipping tape about 5 cm square. You can also sandwich the liquid crystal material between the shipping tape and the top of a clear label. (The latter is used as a liquid crystal sticker when the paper backing is peeled off.) Note: the black plastic provides contrast to enhance the colors of the liquid crystal mixture.

Press on the liquid crystal mixture. What happens?

You can repeat this procedure making another mixture of pressure sensitive liquid crystals by varying the amounts of cholesteryl oleyl carbonate, cholesteryl pelargonate, and cholesteryl chloride. The total mass of the mixture of the three compounds should be approximately 1.0 g.



Preparing temperature sensitive liquid crystal mixtures

Table 1 lists mixtures of cholesteryl liquid crystals that are temperature sensitive. Obtaining exact colour changes at specific temperatures requires precise masses of the liquid crystal materials.
The procedure is similar to that of the pressure sensitive liquid crystal mixtures.
Weigh the liquid crystal materials and place them in a glass vial.
Melt the solid in the vial using a heat gun.
The product changes colour as it cools. Different compositions give different color patterns over different temperature changes.
Make a liquid crystal display.
Using ice water and warm water, determine the temperatures at which the mixture changes colour.

Table 1. Chloesteryl liquid crystal mixtures and their transition temperatures. Different compositions give different color patterns over different temperature ranges.

Cholesteryl oleyl carbonate	Cholesteryl pelargonate	Cholesteryl benzoate	Transition range, degrees C
0.65 g	0.25 g	0.10 g	17-23
0.70 g	0.10 g	0.20 g	20-25
0.45 g	0.45 g	0.10 g	26.5-30.5
0.43 g	0.47 g	0.10 g	29-32
0.44 g	0.46 g	0.10 g	30-33
0.42 g	0.48 g	0.10 g	31-34
0.40 g	0.50 g	0.10 g	32-35
0.38 g	0.52 g	0.10 g	33-36
0.36 g	0.54 g	0.10 g	34-37
0.34 g	0.56 g	0.10 g	35-38
0.32 g	0.58 g	0.10 g	36-39
0.30 g	0.60 g	0.10 g	37-40

[1] The University of Wisconsin-Madison Materials Research Science and Engineering Center, Exploring the Nanoworld, http://mrsec.wisc.edu/Edetc/index.html

Note: Purchasing the cholestryl liquid crystal materials in 10 g to 25 g quantities cost about US$100.00. However, a small amount of material goes a long way.

Questions:

A. Pressure sensitive liquid crystals

1. Describe the behaviour of the pressure sensitive liquid crystal mixture.

2. Is this liquid crystal mixture temperature sensitive? Try exposing it to some cold water or ice. Try exposing it to some warm water.

3. (For a 2nd mixture or more) If you or another group tried a different mixture of pressure sensitive liquid crystal material:

   a) What was the composition of the mixture you used?

   cholesteryl oleyl carbonate __________ g cholesteryl pelargonate ___________ g

cholesteryl chloride ___________ g

b) How did this mixture of liquid crystal materials behave?

4. Can you attribute any differences in behaviour to a specific component of the liquid crystal mixture?

B. Temperature sensitive liquid crystals

1. a) What was the composition of the temperature sensitive liquid crystal mixture you used?

cholesteryl oleyl carbonate ___________ g

cholesteryl pelargonate ___________ g

cholesteryl benzoate ___________ g

b) What was the measured temperature change for this liquid crystal mixture?

c) How did this mixture of liquid crystal materials behave?

2. (For a 2nd mixture or more) If you or another group tried a different mixture of temperature sensitive liquid crystal material:

a) What was the composition of the liquid crystal mixture?

cholesteryl oleyl carbonate ___________ g

cholesteryl pelargonate ___________ g

cholesteryl benzoate ___________ g

b) What was the measured temperature change for this liquid crystal mixture?

c) How did this mixture of liquid crystal materials behave?

3. Can you attribute any differences in behavior to a specific component of the liquid crystal mixture?

David Katz teaches chemistry at Pima Community College, Tucson, Arizona, U.S.A and is well-known for his talks and workshops on chemical experiments. He presented these experiments at a workshop at the 22 ICCE/ 11 ECRICE in Rome in July 2012.

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The development of a textbook on teaching chemistry

Ingo Eilks and Avi Hofstein

Academic textbooks in chemistry – academic textbooks in chemistry education

In 2004, Peter Fensham from Australia published his book ‚Defining an identity – the evolution of science education as a field of research'. Part of Fensham's analysis was to find out whether science education over the years became sufficiently developed to be considered being a self-standing field of academic research. Among other, one criterion for a mature field of research is to whether the researchers in the field of interest have some kind of a joint identity, a joint consent about basic theories and seminal contributions in the field, or an agreement about how to conduct research in the specific domain. In chapter 4 of the book dealing with 'the significance of research' Fensham suggests that a scientific culture of publications is an indicator for a functioning field of research. Fensham discusses the different channels of scientific publications in science education like journals, bibliographies, reviews, handbooks, and edited books and their role for contributing a joint identity of the scientific community. What is not discussed in this chapter – as well as not in chapter 11 on 'research to practice' - is the question about textbooks about science education; textbooks about the theory and practice of science teaching that are written to be used by student teachers in undergraduate or graduate teacher education programs, or used by teachers for their continuous professional development.

A comparison of the sub-domains of chemistry with chemistry education reveals many similarities. Every sub-domain of chemistry research has its own journals, conferences, and handbooks. So does the area of chemistry education. A big difference is that each field of chemistry, e.g. inorganic or physical chemistry, also has a whole set of its own textbooks both for the undergraduate and the graduate level. Most of these textbooks represent some kind of a joint agreement about and comprehensive discussions regarding the most essential facts and theories to be taught and learnt in a specific domain of chemistry at a certain level. These textbooks are often translated into different languages and are available worldwide. This is not the case for chemistry education – there is no set of internationally available and comprehensive textbooks about chemistry education representing a similar joint agreement.

The difference between chemistry and chemistry education is that chemistry is working almost the same all over the world. This is not the case for chemistry education. Chemistry teaching and learning differs from one country to another, sometimes even from one region within a country to one another. The teaching of chemistry is very much determined by national standards and regional syllabi, as well as by national and regional traditions in the curriculum, objectives, and pedagogies. This claim is much more pronounced the case on the school level compared to in higher education. Until today, those few university textbooks on chemistry education available are mainly national textbooks discussing the teaching of chemistry in the foreground of one set of national and regional circumstances. And most of them are not translated. And if they are, they still mirror the view on the field from one regional or national background.

However, if one agrees with Fensham's final claim that science education in general, and chemistry education in particular, became mature fields of academic research and teaching practice, there should be an agreement possible about the most essential facts and theories regarding the teaching of chemistry to be taught in any basic chemistry education course. If this is the case, there should be opportunity to mirror the basic theories in a textbook that will cater for future chemistry teachers to support their education in pre- and in-service teacher education programmes.

A textbook on how to teach chemistry

Starting from the thoughts discussed above, three years ago a group of about 30 chemistry educators from different parts of the world started searching for a mutual consent regarding the most essential facts and theories in the field of chemistry education. The aim was to develop a comprehensive textbook covering the most essential key theories about chemistry education to be used in basic student teacher courses and seminars – and being understandable to the target audience. The goal was to explore these theories and to illustrate them by practical examples and suggestions for classroom practice to allow the learner understanding how theory may lead to changes and innovations into effective practices. The idea was to develop a textbook and not a handbook. In other words this means that the target readers of the book were and are not thought to be researcher's per-se. The target audience were thought to be the student teachers of chemistry, at both undergraduate and graduate level, prospective teachers in courses for chemistry teaching certificates, and practicing teachers who are interested in updating (and enhancing) their knowledge related to chemistry teaching. The book was thought to provide prospective chemistry teachers in their pre-service training and practicing teachers as part of their in-service training with up-to-date background and professional experiences supporting their work as chemistry teachers in both lower and upper secondary school levels.

As a chemistry education textbook, the book was thought to focus developing the reader's Pedagogical Content Knowledge (PCK) in chemistry. The idea of investing in the PCK of the teachers was developed in the late 1980s by Lee S. Shulman (1986). He described PCK as the educational knowledge that is developed by teachers to help others to learn in a specific domain of subject matter knowledge, in our case in chemistry. Shulman differentiated the domain-specific educational knowledge (PCK) from the pure subject matter knowledge (the facts and theories of chemistry) and the general pedagogical knowledge (the theories about learning in general). More applicable to science teaching Magnusson, Krajcik, and Borko in 1999 defined PCK to include five components (adopted from general science teaching to chemistry teaching):

- Orientation towards chemistry teaching to include goals for and approaches to teaching chemistry
- Knowledge of the chemistry curriculum
- Knowledge of students' understanding of chemistry
- Knowledge of chemistry instructional techniques (pedagogy)
- Knowledge of assessment methods in chemistry

Within a core group of potential authors a cyclical approach was adopted to suggest and negotiate the structure of the book and the proposed content each chapter should mirror. Finally the book resulted in 11 chapters, written by 27 authors from 10 countries. See Table 1 for the contents of the book.

Table 1. Chapters of a basic textbook on chemistry education and related theories in the field

Focus	Examples for essential theories	Authors and country
Curriculum	• Teaching chemistry 'for some' or teaching chemistry 'for all' • The theory of the curriculum emphasis • Basic orientations of the chemistry curriculum • Structure-of-the-discipline, history-oriented, context-based, societal-driven, and education for sustainable development curricula	Ingo Eilks (Germany) Franz Rauch (Austria) Bernd Ralle (Germany) Avi Hofstein (Israel)
Objectives and assessment	• Scientific/chemical literacy for all • Domains of chemical literacy • Relevance of chemistry education • Patterns for setting objectives and applying assessment	Yael Shwartz (Israel) Yehudit Judy Dori (Israel) David Treagust (Australia)
Motivation and interest	• Educational psychological theory of interest • Self-determination theory of motivation • Studies about students' interests • Models to enhance motivation	Claus Bolte (Germany) Sabine Streller (Germany) Avi Hofstein (Israel)

Learning difficulties and students' misconceptions	• Constructivism as a theory of knowledge • Different representational levels of chemistry • Problems in the use of models and modelling in chemistry teaching • Factors explaining students' learning difficulties	Onno De Jong (The Netherlands) Ron Blonder (Israel) John Oversby (UK)
Linguistic issues	• Language as mediator in the learning process • Basic problems in learning the language of chemistry • Linguistic heterogeneity as source of problems in chemistry education	Silvija Markic (Germany) Peter Childs (Eire) Joanne Broggy (Eire)
Laboratory work	• Objectives for learning in the laboratory • Different modes of instruction in the chemistry laboratory • Inquiry-based chemistry learning • Problems that inhibit the effect of learning in the laboratory	Avi Hofstein (Israel) Mira Kipnis (Israel) Ian Abrahams (UK)
Teaching methods	• Social constructivism • Models for student active learning environments • Cooperative learning in chemistry teaching • The six mirrors of the classroom model	Ingo Eilks (Germany) Gjalt T. Prins (The Netherlands) Reuven Lazarowitz (Israel)
ICT	• The dual coding theory • Learning chemistry with visual aids and animations • Sensors, data collectors, analysis and communication by ICT	Yehudit Judy Dori (Israel) Sascha Schanze (Germany) Susan Rodrigues (UK)
Informal learning	• Formal, non-formal and informal educational settings • Museums, zoos, newspapers, books, radio, TV, and internet • Industry and school-, university and school-cooperation	Richard K. Coll (New Zealand) John K. Gilbert (UK) Albert Pilot (The Netherlands) Sabine Streller (Germany)
Professional development	• Theories of teacher professional knowledge • Models for continuous professional development • Reflective practice – Action research	Rachel Mamlok-Naaman (Israel) Franz Rauch (Austria) Silvija Markic (Germany) Carmen Fernandez (Brazil)
Teaching in less developed environments	• Teaching chemistry for democratic development • Teaching chemistry for economic development • Teaching chemistry for skills development	Carmen Fernandez (Brazil) Jack Holbrook (Estonia) Rachel Mamlok-Naaman (Israel) Richard K. Coll (New Zealand)

Every chapter provides an easy to read and concise overview regarding the essentials of the theoretical (research-based) background that underline the various key issues in chemistry teaching and learning. In all the chapters the theory is followed by a practical section that provides the readers with examples of effective classroom practice. All chapters apply the theory (of the 1st part) to the practice (in the 2nd part) and provide illustrative examples for theory-driven practice in chemistry teaching. In addition, at the end of each chapter the authors offer a summary of the most essential messages provided in the form of key sentences to be used for self-assessment as well as selected ideas for further reading and a list of relevant websites.

Implications

We do hope that such kind of a book will be of potential to help in aligning classrooms practice with educational theory. We also hope that the readers will benefit from the ideas and will be successful in applying the theories and examples in their various pedagogical and instructional interventions. It was a big challenge to develop such kind of a book. The final result shows that there is a way to consent what should be considered as the most essential facts and theories for a basic textbook in chemistry education – and that such books are needed (Figure 1). It is our hope that in the future there will be more similar initiatives with the goal in mind allowing the prospective chemistry teacher to become familiar with essential theories in science education and also to help lecturers and professional development providers to work with a selection of good textbooks to be used in teacher education courses.

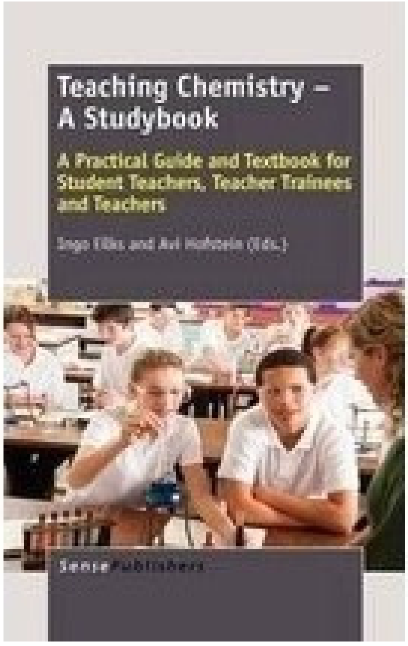
Table 2 1. Some comments about the book

This book, with contributions from many of the world's top experts in chemistry education, is a major publication offering something that has not previously been available. Within this single volume, chemistry teachers, teacher educators, and prospective teachers will find information and advice relating to key issues in teaching (such as the curriculum, assessment and so forth), but contextualised in terms of the specifics of teaching and learning of chemistry, and drawing upon the extensive research in the field. Moreover, the book is written in a scholarly style with extensive citations to the literature, thus providing an excellent starting point for teachers and research students undertaking scholarly studies in chemistry education; whilst, at the same time, offering insight and practical advice to support the planning of effective chemistry teaching. This book should be considered essential reading for those preparing for chemistry teaching, and will be an important addition to the libraries of all concerned with chemical education.

Dr Keith S. Taber (University of Cambridge; Editor: Chemistry Education Research and Practice)

The highly regarded collection of authors in this book fills a critical void by providing an essential resource for teachers of chemistry to enhance pedagogical content knowledge for teaching modern chemistry. Through clever orchestration of examples and theory, and with carefully framed guiding questions, the book equips teachers to act on the relevance of essential chemistry knowledge to navigate such challenges as context, motivation to learn, thinking, activity, language, assessment, and maintaining professional expertise. If you are a secondary or post-secondary teacher of chemistry, this book will quickly become a favourite well-thumbed resource!

Professor Hannah Sevian (University of Massachusetts Boston)



More information on the book and a free preview to selected chapters can be found at www.sensepublishers.com.

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Using word clouds in teaching science

Fiona McManus & Declan Cronin

Teachers are always looking for new or different resources to make their subject more interesting and accessible for pupils. Often the best way to find out about new resources is talking to other science teachers; to see what they have done and how effective it was. This was structured into a recent PDST in UCC for new Science teachers. One method recommended my Fiona McManus (administrator) was the use of word clouds in the classroom.

It has become increasingly difficult to get students to take ownership of their learning. One way that has proven very popular in our school has been in incorporating Tagxedo (www.tagxedo.com) in lesson planning.

Word clouds are a random arrangement of numerous words. The words can be copied from a passage of text or input manually. Depending on the website the words can be organised into specific shapes, colours, and fonts. The most common words input will appear more obvious in the cloud; this allows the pupils to instantly focus on the main words in the word cloud. One of the better sites for making word clouds is tagxedo.com, it allows you to input a URL of a webpage or individual words to create your cloud. (see Figure 1 for an example.)

I was so intrigued by this new idea that I had to try it in my next lesson, during my 4th year teaching practice from the University of Limerick in the Autumn of 2012. I created a word cloud on Acids and Bases I, to ensure there was a large variety of words I copied the Junior Certificate Science notes on the topics from skool.ie: (http://www.skoool.ie/skoool/examcentre_jc.asp?id=4044). After this I used Google images to find a silhouette of a conical flask and uploaded it to Tagxedo (Figure 2).

Figure 1 Food word cloud

Figure 2 Acids and Bases I word cloud

At the beginning of the lesson I informed pupils that we would be revising acids and bases I. I put the word cloud on the board and asked pupils to pick any 3 words and individually write down an explanation with reference to what they know about acids and bases.

After a few minutes suggestions were taken, and other pupils were given the opportunity to discuss the explanations and add to it if needed. This refreshed the topic for the pupils and allowed a solid foundation for me to build on to acids and bases II.

As well as using it to improve literacy and numeracy, we have also used it in Assessment for Learning as students can personalise it by adding their own shapes. Some teachers have found it a welcome change to correct homework / project work in this format as it encourages the learners to think in different ways, including spatially, visually and linguistically and to be more concise in their answers. Teachers find that this type of novel use of technology ensures that lessons appeal to a broader cohort of learners and a variety of learning styles. See below a typical example of the utilisation of Tagxedo, where not only is a word cloud used, but also shape to help re-enforce the learning.

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New elements: names of 114 Flerovium (Fl) and 116 Livermorium (Lv) approved October 2012.

IUPAC has officially approved the name flerovium, with symbol Fl, for the element of atomic number 114 and the name livermorium, with symbol Lv, for the element of atomic number 116. (See new Periodic Table on p. 10)

Priority for the discovery of these elements was assigned, in accordance with the agreed criteria, to the collaboration between the Joint Institute for Nuclear Research (Dubna, Russia) and the Lawrence Livermore National Laboratory (Livermore, California, USA). The collaborating team has proposed the names flerovium and livermorium which have now been formally approved by IUPAC.

For the element with atomic number 114 the discoverers proposed the name flerovium and the symbol Fl. This proposal lies within tradition and will honour the Flerov Laboratory of Nuclear Reactions, where superheavy elements are synthesised. Georgiy N. Flerov (1913 –1990) – was a renowned physicist, author of the discovery of the spontaneous fission of uranium (1940, with Konstantin A. Petrzhak), pioneer in heavy-ion physics, and founder in the Joint Institute for Nuclear Research the Laboratory of Nuclear Reactions (1957). It is an especially appropriate choice because, since 1991 this laboratory in which the element was synthesized, has borne his name. Professor G.N. Flerov is known also for his fundamental work in various fields of physics that resulted in the discovery of new phenomena in properties and interactions of the atomic nuclei; these have played a key role in the establishment and development of many areas of further research.

For the element with atomic number 116 the name proposed is livermorium with the symbol Lv. This is again in line with tradition and honours the Lawrence Livermore National Laboratory (1952). A group of researchers of this Laboratory with the heavy element research group of the Flerov Laboratory of Nuclear Reactions took part in the work carried out in Dubna on the synthesis of superheavy elements including element 116. Over the years scientists at Livermore have been involved in many areas of nuclear science: the investigation of fission properties of the heaviest elements, including the discovery of bimodal fission, and the study of prompt gamma-rays emitted from fission fragments following fission, the investigation of isomers and isomeric levels in many nuclei and the investigation of the chemical properties of the heaviest elements.

The naming of elements 113, 115, 117 and 118 is under discussion by a IUPAC/IUPAP joint committee.

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Proceedings 31st ChemEd-Ireland,
Dublin City University, 20th October 2012.

31st ChemEd-Ireland
20th October
Dublin City University

The 2012 ChemEd-Conference in DCU was different to those in previous years as there were more workshops and less talks. The programme is given below. There were two main workshop sessions, one in the morning and one in the afternoon and a choice of three possible workshops. The conference was influenced by the two FP-7 EU projects going on at DCU – Establish and SAILS, both of them concerned with Inquiry-Based Science Education (IBSE). Establish is developing new inquiry-based teaching materials with an emphasis on applications and one of the workshops gave participants a chance to sample some of the activities. SAILS is concerned with assessment of IBSE and Christine Harrison's plenary lecture was concerned with the issue of assessment. There were also talks by Anna Walshe of the NCCA on developments in the revised LC Chemistry syllabus.

Odilla Finlayson (L) with Christine Harrison (R)

Programme
9.30 a.m. **Presentation: *How Might We Assess Inquiry in Science?***
Christine Harrison,
King's College London, UK
11.00 a.m. – 12.00 noon and 12.00 noon -1.00 p.m.
Choice of Workshops:
Developing expertise in teaching Redox Chemistry – getting to grips with electrons!
Iris Suitor & Angela McKeown, RSC
Examples of Chemistry topics by Inquiry from the EU-FP7 ESTABLISH project
Stefanie Herzog, IPN, Germany
Chemistry is All Around Network Project - the Irish perspective
Marie Walsh, LIT, Ireland
1.00 – 2.00 p.m. Lunch
2.00 – 4.00 p.m. **Presentation & Workshop:**
Leaving Certificate Chemistry- what's happening?
Anna Walshe, National Council for Curriculum and Assessment

Iris Suitor who helped lead the RSC workshop

More photos of ChemEd-Ireland 2012 overleaf.

Photoessay

For more photos of the conference see the Dropbox: https://www.dropbox.com/sh/eli764xv7tn40am/GpCBO2STbL

Coffee is an important time to catch-up with old friends

One of the practical workshop sessions

Busy bees in the laboratory

Lunch is also a good time to chat as well as eat

Practical work is about talking as well as doing

Some well-known chemists taking the air

Assessing Science Inquiry

Chris Harrison
Science and Technology Education Group, King's College, London
christine.harrison@kcl.ac.uk

Inquiry based science education (IBSE)

Inquiry skills are what learners use to make sense of the world around them. These skills are important both to create citizens that can make sense of the science in the world they live in so that they make informed decisions and also to develop scientific reasoning for those undertaking future scientific careers An inquiry approach not only helps youngsters develop a set of skills that they will find useful in a variety of contexts, it can also help them develop their conceptual understanding of science inquiry based science education (IBSE) and has been promoted by international reports such as the Rocard report, (2007) to encourage students motivation and engagement with science. Over the last few years, there have been several large scale projects funded under the European Seventh Framework programme focused on the use and implementation of IBSE such as S-TEAM, ESTABLISH, Fibonacci, PRIMAS and Pathway. The outcomes from these projects in terms of reports and materials are now available through the world wide web. These projects have been successful in highlighting the importance of IBSE across Europe and also have allowed us to determine the range of understanding of what the term inquiry means, and to establish to what extent skills and competencies that are developed through inquiry practices have been identified.

The term *inquiry* has figured prominently in science education, yet it refers to at least three distinct categories of activities—**what scientists do** (e.g., conducting investigations using scientific methods), **how students learn** (e.g., actively inquiring through thinking and doing into a phenomenon or problem, often mirroring the processes used by scientists), and a **pedagogical approach that teachers employ** (e.g., designing or using curricula that allow for extended investigations) (Minner, 2009). However, whether it is the scientist, student, or teacher who is doing or supporting inquiry, the act itself has some core components.

Inquiry based science education is an approach to teaching and learning science that is conducted through the process of raising questions and seeking answers. An inquiry approach fits within a constructivist paradigm in that it requires the learner to take note of new ideas and contexts and question how these fit with their existing understanding. It is not about the teacher delivering a curriculum of knowledge to the learner but rather about the learner building an understanding through guidance and challenge from their teacher and from their peers.

Some of the key characteristics of inquiry based learning are:

- Students are engaged with a difficult problem or situation that is open-ended to such a degree that a variety of solutions or responses are conceivable.
- Students have control over the direction of the inquiry and the methods or approaches that are taken.
- Students draw upon their existing knowledge and they identify what their learning needs are.
- The different tasks stimulate curiosity in the students, which encourages them to continue to search for new data or evidence.
- The students are responsible for the analysis of the evidence and also for presenting evidence in an appropriate manner which defends their solution to the initial problem (Kahn & O'Rourke, 2005).

These characteristics are reflected in the NRC's (2000) "essential features of classroom inquiry". These include:

- "*Learners are engaged by scientifically oriented questions.*
- *Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.*

- *Learners formulate explanations from evidence to address scientifically oriented questions.*
- *Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding*
- *Learners communicate and justify their proposed explanations"* (NRC, 2000, p. 25)

Within an inquiry culture there is also a clear belief that student learning outcomes are especially valued. One characteristic of inquiry learning is that students are fully involved in the active learning process. Students who are making observations, collecting data, analyzing data, synthesizing information, and drawing conclusions are developing problem-solving skills. These skills fully incorporate the basic and integrated science process skills necessary in scientific inquiry. A second characteristic of inquiry learning is that students develop the lifelong skills critical to thinking creatively, as they learn how to solve problems using a logic and reasoning. These skills are essential for drawing sound conclusions from experimental findings. While many projects have focused on the evaluation of conceptual understanding of science principles developed, there is a clear need to evaluate other key learning outcomes, such as process and other self-directed learning skills, with the aim to foster the development of interest, social competencies and openness for inquiry so as to prepare students for lifelong learning. This has been the aim of the IBSE Framework 7 projects so far.

So the move to implement more IBSE type learning across Europe has been successful in terms of raising awareness of the importance of this approach but the introduction of these ideas into mainstream teaching and learning has been less readily taken up. In the UK, we know that generally science practicals are presented as recipes to follow so that students experience scientific phenomena.

This approach means that the raising of questions about phenomena lies with the teacher rather than the student. So, in most science practicals, the student role is collecting and presenting data that is then made sense of by the teacher
This approach to practical work does not aid conceptual development nor understanding and development of inquiry skills beyond practice of a limited number of skills

Part of the reason for this slow implementation of IBSE in science classrooms is the time lag that happens between introducing ideas and the training of teachers at both inservice and preservice level. While this situation should improve over the next few years, there is a fundamental problem with an IBSE approach and this lies with assessment. While the many EU IBSE projects have produced teaching materials, they have not produced support materials to help teachers with the assessment of this approach. Linked to this is the low level of IBSE type items in national and international assessments which gives the message to teachers that IBSE is not considered important in terms of competence in science education. It is clear that there is a need to produce an assessment model and support materials to help teachers assess IBSE learning in their classrooms if this approach is to be further developed and sustained in classrooms across Europe.

Assessment Approach

The Strategies for Assessment of Inquiry Skills in Science Project (SAILS) is a new EU Framework 7 project, currently in its second year of development and set up to help with developing inquiry based science education across Europe. The prime aim of this project is to produce and trial assessment models and materials that will help teachers assess inquiry skills in the classroom. At the centre of this work is Assessment for Learning. Two of the lead members of the King's College London team Chris Harrison and Paul Black have been working with a pilot group of 16 expert science teachers developing the first round of materials for the project. The materials produced are then being trialled in 13 different countries to see how the approach fits within different cultural contexts. Three topics have been selected for the first set of materials – Food, Rates of Reaction and Speed and Acceleration.

Teachers need to recognize and collect the assessment data that arises from inquiry lessons. To do this they need to think carefully about the variety of ways in which learners might respond to the new ideas or new contexts or challenging question being offered. Being aware of a quality answer to a problem will help teachers easily recognize whether a child has or hasn't got that understanding. A way forward might be to ask the teacher to highlight each of the challenges in an inquiry lesson and to note how good understanding of that challenge could be demonstrated.

By listening carefully to answers to questions or to group discussion or by scrutinizing products from inquiry activities, teachers can gather evidence of their learners' emerging understanding. Teachers can note misconceptions, identify partly answered questions from full answers, and recognize errors and possible reasons why such errors are occurring. Such data is rich in inquiry lessons because the very nature of the approach means that the lesson is challenging and so understanding is interrogated.

Observing learners in the classroom as they carry out investigations, listening to learners piece together evidence to answer a challenging question in a group discussion, reading through answers to homework questions and watching learners respond to what is being offered as possible solutions to problems all provide plentiful and rich assessment data for teachers. Such data place teachers in a good position to sum up the progress and to have a realistic awareness of each learner's understanding by the end of the learning sequence of activities.

This type of assessment has high validity. It satisfies one of the conditions for validity in having high reliability, in that the learner is assessed on several different occasions, thereby compensating for variations in a learner's performance from day to day, and in several ways, thereby sampling the full range of learning aims. The fact that the learner has been assessed in contexts which have been interspersed with the learning secures both coverage and authenticity, particularly because the teacher is able to test and re-test her interpretations of what the data mean in relation to each individual's developing understanding. Such data place teachers in a good position to sum up the progress and to have a realistic awareness of each learner's understanding by the end of the learning sequence of activities. This is radically different from assessing the learner in the artificial context of the formal test, and it is far more valid i.e. the teacher can be far more confident in reporting – to a parent, or to the next teacher of the learner, or to any others who might want to have and use assessment results – about the learner's potential to both use and to extend her learning in the future.

The SAILS pilot so far looks promising. Teachers have reported that they feel that they gain far more evidence of student performance by collecting evidence during the inquiry activities than from marking reports of the inquiry. They also are able to feed evidence back into their teaching and so respond formatively to booth the needs and progress of learners.

For more information on the SAILS project – www.sails-project.eu

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Dr. Christine Harrison worked in secondary schools for 13 years before joining King's to run the Biology Education section. Her teaching and research have centred on assessment, science education, cognitive acceleration and the use of text and TV in classrooms. She led the Royal Society Assessment 14-19 Science project, the King's Researching Expert Science Teaching project (KREST) and the King's-Oxfordshire Summative Assessment Project (KOSAP) as well as taking consultancy roles with Assessment for Learning Projects in the USA, Jersey, Wales, Scotland, Peru and London. She has also been co-opted onto the Association for Science Education Council to advice on and support initiatives on assessment and professional development.

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RSC Learn Chemistry CPD event

Angela McKeown and Iris Suitor

The Royal Society of Chemistry is the leading organisation in Europe for advancing the chemical sciences and is supported by a network of 45,000 members worldwide.

The education team have developed a fantastic range of supports for Chemistry teachers available through their award winning **Learn Chemistry** website where teachers can access free Chemistry teaching resources including a number of the RSC books at www.rsc.org/learn-chemistry

Lately, the team have been working on the development of a range of CPD modules which cover some key concepts in Chemistry as a support for teachers in secondary schools and colleges across the UK and Ireland. As a result, around 40 teachers at the ChemEd conference got a chance to sample a free trial version of the module on "Redox Chemistry" which has been designed to explore the topic through a range of simple and colourful experiments.

The RSC trainer Iris Suitor delivered the workshop which provided a 'hands-on' opportunity for teachers to explore effective strategies for teaching redox chemistry across the 11-19 age range including some microscale work using simple equipment and minimal chemicals for achieving quick results, and an exciting demonstration on turning a copper coin into silver and then gold! Teachers were able to take a look at some different approaches to experiments they could use when teaching this topic, share ideas and work together as well as follow up their knowledge with the probing questions on the worksheets.

A very simple but effective experiment suitable for pupils included investigating the real reactivity of Aluminium. A small square of aluminium foil is placed in 5 cm3 of 0.5M copper (11) sulphate solution (harmful) and pupils are asked to record their observations in regard to bubbles, colour change, temperature change and copper observed. Then a spatula measure of sodium chloride is added and allowed to dissolve. Pupils are then asked to repeat their observations.

Experiment/demonstration: **Investigating the *real* reactivity of aluminium**

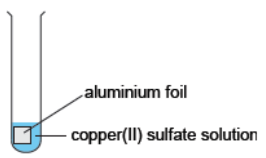
Requirements:

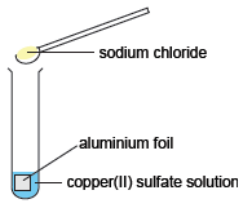
- boiling tube
- spatula
- stirring rod
- aluminium foil square, ~ 2 cm x 2 cm
- copper(II) sulfate solution, ~ 0.5 M
- sodium chloride (table salt)

***Outline* instructions:** **WEAR EYE PROTECTION**

1. Pour approximately 5 cm^3 of copper(II) sulfate solution* into the boiling tube.
2. Add a square of aluminium foil.
3. Look for any signs of a reaction. Record your observations.
4. Now add a spatula measure of sodium chloride. Stir to dissolve.
5. Observe any changes. If nothing happens – add a little more sodium chloride.
6. Record all your observations. How can you explain what happens?

* Treat the copper sulfate solution as harmful and dangerous for the environment. Dispose of as required by the venue.





Observations	Before the salt is added	After the salt is added
Bubbles?		
Colour change?		
Temperature change?		
Copper observed?		

Teachers could use this experiment to teach pupils observation skills, to demonstrate oxidation on the surface of aluminium foil and why it is used in food preparation and storage, or it could be developed further to generate discussion in terms of reactivity series, ionic and half equations.

The demonstration on turning a copper coin into silver and gold can be achieved by making up a solution of sodium zincate using excess zinc and sodium hydroxide. When the copper coin comes in contact with the excess zinc, zinc plating takes place, involving an electrochemical cell. The coating of zinc gives the impression of a silver coin. On heating, brass is formed when the zinc migrates into the surface layer of the copper, giving a gold appearance to the coin. The experiment can be developed further with the pupils by looking at the electrode reactions at the zinc and copper electrodes.

The experiment details for this demonstration can be found in Learn Chemistry and includes teachers' notes and a video to show to the pupils. You can find these at http://www.rsc.org/learn-chemistry/resource/listing?searchtext=sodium+zincate

While you are on there, why not try typing "redox" into the search box on the Learn Chemistry website to see around 500 resources that you can access for free! You can use the toolbar on the left hand side to sort the resources by category, including "resource type" and "age group". Our "starters for 10" worksheets are extremely popular and a number of redox worksheets can be found at
http://www.rsc.org/learn-chemistry/resource/res00000954/starters-for-ten#!cmpid=CMP00001413

Before you go, don't forget to use the toolbar on the right hand side to sign up for the Learn Chemistry newsletter which will tell you about exciting new resources that are put up, for example the news that, by per popular demand, *Chemical Misconceptions – prevention, diagnosis and cure, Volume I: Theoretical Background* by Keith Taber has just been added to Learn Chemistry. This resource includes information about some of the key misconceptions that have been uncovered by research and ideas about a variety of teaching approaches that may help avoid students acquiring some common misconceptions.

Good luck with your Chemistry teaching and don't forget to contact your RSC regional coordinator Angela McKeown at a.mckeown@qub.ac.uk if you have any questions about RSC resources, courses or events. We hope to see you at ChemEd-Ireland again this year, where we will be running another RSC Learn Chemistry CPD course!

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Chemistry Is All Around Us Network

Project Report: Year 2 Teacher Training

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The Chemistry Is All Around Network Project involves thirteen partners from eleven European countries. As reported in previous issues of *Chemistry in Action!* the aim of this Comenius-funded project is to encourage lifelong learning in Chemistry. To this end a collection of links to ICT-based resources has been gathered on the web portal at www.chemistryisnetwork.eu

The second year of the project is considering issues in science/chemistry teacher training. A number of publications from each country have been gathered and a paper summarising teacher training in the country produced. Each group held a workshop to discuss the issues pin-pointed in the publications and papers. The Irish workshop on teacher training took place on May 28th 2013. The focus was Teacher Training and Continuous Professional Development, and the relevance of the Chemistry Is All Around Network Project to these. The following items were discussed within an Irish context:

Consecutive Versus Concurrent training of student teachers:

The value of each type was significantly dependant on several key factors including the student; the particular philosophy of the department or third level institute; the delivery mode (and the 'lecturers') and the motivation or student's perception of what a chemistry teacher is. It was decided that there are advantages and disadvantages to each method and that a blend of both would be ideal but difficult to achieve. However, subject content knowledge was identified as possibly lacking in the case of concurrent training.

Pre-service and In-service training:

To date pre-service training for primary school teachers has not been evident. However, this is currently being addressed at undergraduate level but the benefits will not be seen for four years i.e. graduates of 2017. In-service training in the Irish context is not a mandatory requirement for teachers at either primary or secondary level but uptake of such training where available is significant despite it usually being outside of 'normal' working conditions with no recognition by the education department nor incentive.

Probation and Induction:

The group felt that a science mentor either within a school or locally among a community of schools would be of huge benefit to teachers. The potential for a third level lecturer to be engaged in such a role is worth exploring.

Continuous Professional Development (CPD):

Courses are run on a regular basis for second level teachers of science/chemistry and the need for these is evident in the fact that the courses are oversubscribed and that waiting lists exist. One recurring theme emerged, that of 'Misconception' of chemistry concepts by student teachers being passed on to the secondary level students.
The use of ICT was discussed. It was felt that, while the future of the teaching of science/chemistry would involve ICT given its

prevalence in everyday life, there should be a focus on the technique of blended learning to include traditional teaching methods.

Methodologies to teach specific topics:

The use of various media and ICT as tools for teaching which are either available as packages or a group based project was discussed. Some examples were discussed in depth and it was felt that such teaching was often time consuming and was too liberal as a method when the syllabus is so well defined. It was also felt that both students and parents are focused on the exam process and the final grade as opposed to the topic of chemistry. To that end it was felt that such a project style using blended learning should be incorporated into the learning.

The importance of **training science teachers to keep up to date** with the continuous progress of research was dictated by the recommended texts for the subject and the extra-curricular activities engaged with by teachers and students such as SciFest and the BT young scientist competition. It was felt that CPD also has a role to play here.
The **use of simulations** has a major drawback regarding cost and relevance to the syllabus. While there are many resources available the detail and relevance does not always match the syllabus learning outcomes and has limitations in either being too detailed and in depth or not enough. There may be a possibility to develop such resources specifically for the Irish situation. Simulations have a role in a blended learning environment but it was also noted that such learning resources are taxed at 23% in Ireland and possibly to a similar extent in Europe.

International Meeting in Gabrovo Bulgaria

The project partners met for two days in June in Gabrovo, Bulgaria. The town is only 11km from the geographical centre of Bulgaria, high in the mountains. Having travelled such a distance to get there it was fantastic to feel a sense of achievement at the end of two days of meetings and presentations. The partners presented the situation in the individual countries at a conference in the Aprilov High School on June 26th.

CIAAN Project partners in Bulgaria

There is no doubt there are common issues across Europe with regard to training of science teachers and it is interesting to hear if or how these issues are being addressed. Recurring points for debate included Misconceptions transmitted from teachers to students, Concurrent versus Consecutive Training, the value of structured Mentoring, the need for Probation and the vital importance of (compulsory) Continuous Professional Development.

Currently the partnership is continuing to gather information from the individual countries and this will be further presented and discussed at the next meeting in Limerick in November 2013. The two days of partner meetings will be followed by a conference on November 29th in Limerick Institute of Technology. Further information on the International Conference on Issues in Science/Chemistry Teacher Training will be posted, with a call for abstracts on the LIT website www.lit.ie in the near future. Participation at the conference will be free except for the cost of lunch. It is hoped that a good representative audience of teacher trainers and teacher practitioners will attend to inform the debate. For further information about the project please check the project portal at www.chemistryisnetwork.eu or contact Marie.Walsh@lit.ie

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Ideas for teaching Fuels and Octane Ratings in Leaving Certificate Organic Chemistry

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Introduction:

This article is the second in a series of short articles taken from the *Organic Chemistry in Action!* teaching materials (Issue 95, pages 8-15). An article 'Introducing Isomers for Leaving Certificate Organic Chemistry' was published in Issue no. 98 of *Chemistry in Action!* (O' Dwyer & Childs, 2012).

We will now take a closer look at another Leaving Certificate Organic Chemistry topic: Fossil Fuels and understanding Octane Numbers to improve the octane rating of fuels.

The Leaving Certificate Chemistry (DES, 1999) requires pupils to understand:

- Fractionation of crude oil.
- Production and uses of the refinery gas, light gasoline, naphtha, kerosene, gas oil and residue fractions.
- Composition of natural gas and liquid petroleum gas (LPG).
- Addition of mercaptans to natural gas for safety reasons.
- Composition of petrol.
- Auto-ignition.
- Octane numbers as a measure of the tendency of a fuel to cause knocking.
- Lead in petrol and alternatives to lead.
- Improving octane number by:
  (i) isomerisation
  (ii) dehydrocyclisation
  (iii) catalytic cracking.
- *Internal combustion engine in relation to auto-ignition.*
- *Relationship between octane number and*
  (i) chain length
  (ii) degree of branching
  (iii) cyclic structure.
- *Adding oxygenates (notably methyl tert-butyl ether) to increase the octane number and reduce pollution (structure of methyl tert-butyl ether not required).*

The content listed in *italics* above is specified as Higher Level content on the Chemistry syllabus. The rest of the content is common to both levels. (Please note, not all of this content is included in this article).

Learner Misconceptions:

Fuels as a source of energy:
Pupils may not understand that fossil fuels provide energy. The energy supplied by the fossil fuels is stored energy (chemical energy) that was originally derived from the sun (heat energy), via photosynthesis. These fuels can then be burned to produce heat, which can be turned into electrical energy.

Inter and intra molecular bonding - What happens when something boils?
It is important to ensure, before introducing the process of fractional distillation, that the pupils have a clear understanding of what happens to the molecules in a liquid when it boils. A common misconception is that the intramolecular bonds (bonds holding atoms together inside the molecule) are broken releasing individual atoms. It may be necessary to revise the difference between intra- and inter- molecular bonds. It should be stressed that covalent bonds are intramolecular bonds and are strong and not easily broken. Intermolecular bonds (due to van der Waal's forces) bond molecules to each other and are weak and easily broken. Questions as shown in Figure 1 below are useful to identify and address misconceptions about boiling liquids.

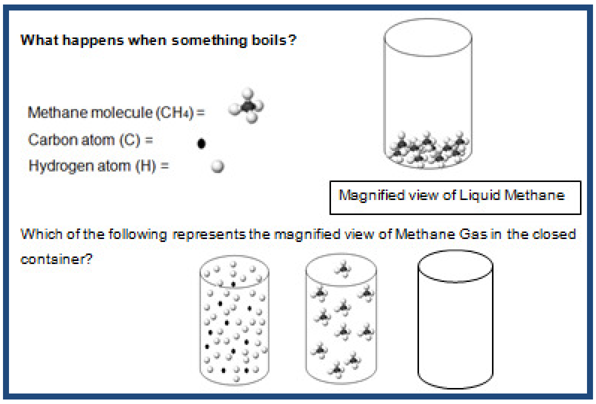


Figure 1. Molecular illustration to identify misconceptions about inter- and intramolecular bonding.

Possible difficulties:

Separation of mixtures

It is useful to probe the pupils' recall of what they have learned about separating mixtures in their Junior Certificate Science. It is important at this point that the pupils understand the principle underlying each separation method, as well as details of the method itself e.g. solubility, miscibility, boiling point etc.

Fractional distillation only involves physical changes and the molecules are unchanged.

Physical and Chemical changes

The processes of distillation and fractional distillation should be discussed with the pupils. Pupils need to understand that distillation only involves a physical change (of state) of the hydrocarbon compounds and not any chemical change of their composition.

However, other processes, such as those to improve octane rating (isomerisation, reforming and catalytic cracking) do involve chemical changes as new products are formed.

The use of the molecular models in this lesson is essential to facilitate the pupils' understanding of how isomerisation, reforming and catalytic cracking change the shape and size of the hydrocarbons to increase their Octane Number. Giving pupils the opportunity to physically manipulate molecular structures facilitates the understanding of the new concepts of reforming and catalytic cracking in particular.

New Vocabulary

Volatile:

A common misconception with pupils is that volatile means 'useful'. Volatility is a measure of how readily a substance vaporises and is related to their boiling points. This can be explained by discussing why diesel (longer carbon chain) is less volatile than petrol (shorter carbon chain).

Reforming:

This term is also called 'dehydrocyclisation'. When this word is broken down for the pupils as 'de-hydro' (removal of hydrogen) 'cyclisation' (ring forming), the pupils will gain a better understanding of the term. To reform means to change one molecule into another one i.e. to change its form.

Catalytic cracking:

This term should be broken down. Pupils should be familiar with catalysts (as something that alters the rate of a reaction, without being used up). Cracking refers to the breaking of a longer chain into shorter and branched chains.

Pupil Activity 1- *Separation of Hydrocarbon mixture:*

This activity can be introduced though a discussion about separation of mixtures:

- Separating sand and salt,
- Salt and water
- Ethanol and water

Pupils should be probed to think about the property that determines the particular separation technique i.e. solubility, boiling point etc. A discussion about the separation of ethanol and water (by distillation) should prepare the pupils for the separation of hydrocarbons and introduce the new concept of fractional distillation.

Materials required (per group of pupils):

- Pyrex test-tube with a side arm.
- Bung with a hole (for thermometer).
- Thermometer (0-360° C)
- Glass tubing (with a bend)
- 3 x collecting flasks (small test tubes)
- Bunsen burner (heating mantle if available)
- Retort stand.
- 100 cm^3 beaker.
- Water.
- Ice.
- Glass wool.

Chemicals required (per group of pupils):

- Imitation sample of Crude Oil

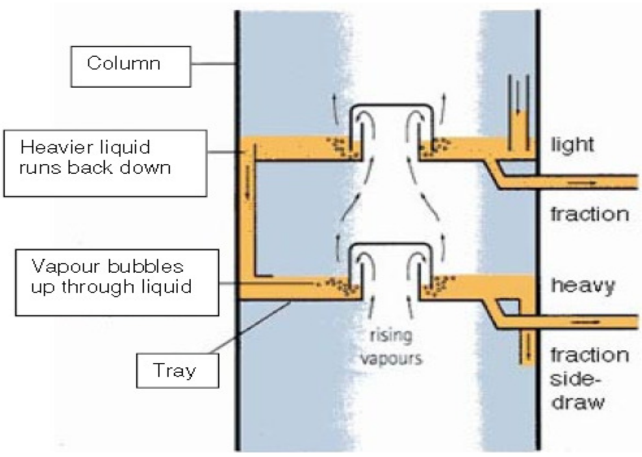


Figure 2. Bubble cap in a refining column. Image modified from Schoolscience.co.uk, available at: http://resources.schoolscience.co.uk/EnergyInstitute/14-16/fossils/p8.html

Preparation before the lesson:
Prepare an imitation mixture of crude oil before the lesson. Sample fractions may include:

- Petrol (BP range 0-70°C)
- Liquid Paraffin (BP range 70-150 °C).
- White Spirits (BP range 150-190 °C)
- Lubricating Oil (BP range 300-370 °C)
- Paraffin Wax (BP range >370 °C)

Note: You will have to tell your pupils the boiling point (BP) range of the components in their hydrocarbon mixture.

N.B. Safety: A bunsen burner can be used if a heating mantle is not available, but ideally heating mantles should be used. However, this separation must be closely supervised as the hydrocarbon mixture is highly flammable if exposed to a naked flame. Use only small amounts of the hydrocarbon fractions.

Procedure:
1. Pour some of the hydrocarbon mixture into the bottom of a pyrex test-tube.
2. Using a glass rod, push some glass wool down to the bottom of the tube to soak the sample.
3. Set up the apparatus for distillation (as shown in the diagram) clamping the heated test-tube at the top with a retort stand. Note the use of glass delivery tube.
4. Place the collection test-tube in a beaker of iced water.
5. Heat the test-tube gently using a Bunsen burner.
6. Collect the first fraction (shortest hydrocarbon) at the given temperature.
7. Once the temperature range of the first fraction is passed, change the collection test-tube.
8. If paraffin wax is used, this fraction will remain in the test-tube at the end of the distillation.

This activity is adapted from an alternative method for the distillation of the hydrocarbon mixture. This is available at the Nuffield Foundation Practical Chemistry at: http://www.nuffieldfoundation.org/practical-chemistry/fractional-distillation-crude-oil

Teacher Notes:
It is important to use at least two different fractions in the mixture. Ensure that the reactions used have very different boiling point ranges so that they can be separated easily by distillation. The pupils must also know that the mixture given to them is composed of three hydrocarbons with different chain lengths. The pupils should deduce that the longer chain carbons have higher boiling point because they have stronger intermolecular bonds.

The procedure for this experiment is included here in the teacher notes and deliberately omitted from the Pupil Handout. Pupils can work in small groups to suggest a safe method to carry out this investigation before presenting the experimental instructions to them.

From this activity, pupils should learn that in a fractional distillation process, the fractions with the lower boiling points are separated first.
This experimental activity should help pupils to understand how crude oil is separated in the fractional distillation columns in an oil refinery as shown in Figure 2.

Pupil Activity 2: *Factors affecting Octane Rating*

This activity sheet was adapted from Denby, Otter & Stephenson (2008), *Chemical Storylines,* Salters Advanced Chemistry: Developing Fuels.

In working through this activity sheet, the pupils should deduce the factors that contribute to a high octane rating of a fuel; shorter chains and more branched chains. The cyclisation of chains will be introduced in the reforming (model making exercise) in Activity 3 that follows.

Pupil Activity 3: *Improving Octane Rating*

This activity is divided into three sections to indicate the three ways in which the octane rating of a fuel can be improved.
The pupils work in groups using the molecular modelling kits to form isomers, reform and crack hydrocarbon chains.
Group and class discussion and teacher questioning are important during this activity to illustrate the number of different possible structures.
The reference table (Figure 3) of octane numbers will need to be copied and provided to the pupils for use with Activity 3- Improving Octane Rating.

Table of Octane Numbers	
Hydrocarbons	**Octane Number**
Straight Chain	
Pentane	62
Hexane	25
Heptane	0
Octane	-10
Branched	
2-methylbutane	93
2,2-dimethylpropane	80
2,2-dimethylbutane	93
2,3-dimethylbutane	94
2-methylhexane	46
3-methylhexane	55
2,2,4-trimethylpentane	100
2,2,3-trimethylpentane	110
Cyclic	
Cyclohexane	83
Methylcyclohexane	70
Benzene	106
Methylbenzene	120

Figure 3. Reference Table of Octane Numbers

Isomerisation

The activity of making the straight chained pentane and two branched isomers is a useful revision of structural isomers. Writing the octane number with each structure reinforces the effect that shape and chain length has on octane number.

1. Reforming (Dehydrocyclisation)

In this activity, the pupils use the molecular models to see the changes in forming cyclohexane from hexane. The pupils can see that two hydrogen atoms are not used, which are used in the previous structure. This highlights the loss of one molecule of hydrogen in the process. The pupils can also investigate how many more hydrogen atoms need to be removed to make benzene. Pupils can refer to the table of octane numbers (Figure 3) to see that cyclic and aromatic compounds have higher octane numbers than straight, open chained hydrocarbons.

2. Catalytic Cracking

This activity prepares the pupils before carrying out the laboratory practice of catalytic cracking. As each group may make different possible products from the long starting chain after cracking, the pupils should be able to conclude that there are many possible ways in which long chains may be cracked producing different products. In comparing their own products and products from other groups with the one starting material, pupils should recognise that at least one of the products will have to be unsaturated.
Under different conditions of heat / pressure, different products may be formed.
For example, four possible products may be obtained from hexadecane ($C_{16}H_{32}$): propene, 3-methylheptane, ethene and propane.

Teacher Demonstration- *Internal Combustion Engine Demonstration*

Materials required:

- Large glass coffee jar (about 1L volume).
- Piece of thick cardboard (A beer-mat is the appropriate size).
- Scissors.
- Hole-puncher.
- Match.
- Plastic dropper or small syringe.
- 2-3 cm^3 of petrol.

Preparation before the class:
Make sure that the glass jar being used does not have a lip at the top. A beaker will not do as the cardboard disc needs to fit flush on the top. Cut the cardboard into a disc of the same diameter as the glass jar.
Use the hole-puncher, scissors or a nail to make a small hole in the centre of the cardboard disc.

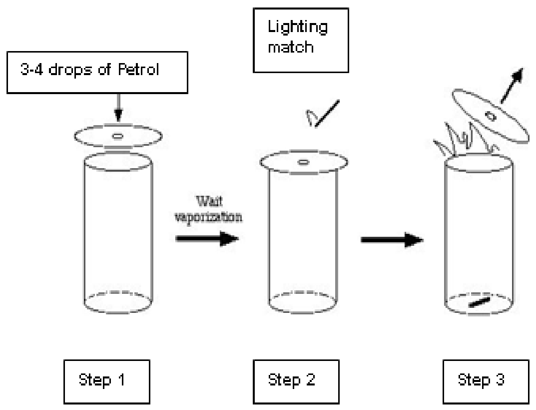


Figure 4. Step-wise procedure to demonstrate internal combustion.

NB. Safety: Only a small amount of petrol is necessary for this demonstration. Never have a naked flame close to the petrol container. Make sure that you try this demonstration out before the lesson and are confident you can carry it out safely.

Procedure (Figure 4):
1. Cover the opening of the container with the punched disk.
2. Explain that the volume of the chamber (1 L / 1000 cc) is about the same as the cylinders in a 1-litre car engine.
3. Using the plastic dropper or small syringe inject the flask with 3-4 drops of petrol through the hole of the disk.
4. Wait for about 30 seconds until the petrol has vaporised.
5. (You may put the lid on the coffee jar and shake for a minute to ensure the petrol is vaporised).
6. Light a match and quickly throw it in through the hole in the disk without touching the edge.

The gaseous mixture explodes nearly noiselessly and projects the cardboard disk a couple of centimetres in the air.

Explanation:
The one litre coffee jar contains (~20%) about 200 cm^3 O_2, which is about 0.009 mol O_2. For ideal combustion, this requires 12.5 times less petrol, i.e. 0.0007 moles (0.1 g) or 4 drops.
The number of drops of petrol added can be changed. With less than 2 drops, nothing happens. With more than 8 drops, the explosion misfires. With about 20 drops, the mixture burns like a candle when the disk is removed. The explosive reaction between petrol and air when ignited in this demonstration is the same as that in the cylinders of an internal combustion engine. It is important that this similarity is recognised by the pupils.
This demonstration was sourced from Maurice Cosandey (2006), Federal Institute of Technology Lausanne, Switzerland. Further details are available online at: http://sevelin44.educanet2.ch/chimie.cosandey/chem.exp/

Possible Lesson Extensions

The 'Whoosh' Bottle Demonstration
The experiment demonstrates dramatically just how much chemical energy is released from such a small quantity of fuel. The flame colour varies with the proportion of carbon in the fuel molecule. Details of this demonstration are available to download from the RSC-Learn Chemistry resources at: http://www.rsc.org/learn-chemistry/resource/res00000708/the-whoosh-bottle-demonstration?cmpid=CMP00000786

Catalytic Cracking of liquid paraffin

Materials required (per group of pupils):
- 1 litre Ice-cream container.
- 2 test-tubes (with stoppers to fit).
- Boiling tube.
- Rubber bung (with one hole)
- Glass Tubing (short piece, inserted into the bung)
- Rubber Tubing.
- Lighter.
- Retort stand.
- Glass rod.
- Bunsen burner.
- Pieces of porcelain.
- Tapers.

Chemicals required (per group of pupils):
- 5 cm^3 liquid paraffin.
- Glass wool.
- Water.
- 5 cm^3 bromine water.
- 5 cm^3 acidified potassium permanganate solution.

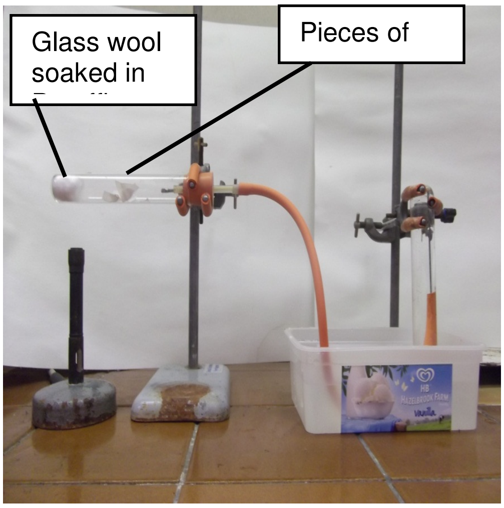


Figure5. Photo of set up for catalytic cracking of paraffin using porcelain

Procedure:
This experiment can be set up as shown Figure 5. The paraffin is heated and vaporises. S it passes over the hot porcelain chips it is cracked and smaller molecules are produced and collected over water. The products can be tested for unsaturation by using dilute bromine water and potassium permanganate solution (which are both decolorised by reaction with double bonds).

Future Lessons

Additives to improve octane rating:
It is important that the pupils understand the advantages (oxygen containing alcohols, Methyl-Tert-Butyl Ether, MTBE) and disadvantages (benzene, lead) of adding particular additives. Pupils may be asked to decide on what they think the best additive would be and to explain why. It may be worthwhile burning a small amount of ethanol or methanol as a demonstration to allow pupils to observe the blue flame. The Whoosh Bottle demonstration also illustrates the combustion of an oxygenated fuel.

Hydrogen as a Fuel:
Hydrogen for use as a fuel can be produced by:

- Steam Reforming
- Electrolysis of water

Biofuels:
Biodiesel is typically made by chemically reacting lipids (e.g. vegetable oil, animal fat) with an alcohol (methanol).
This process of converting vegetable oil in to biofuel (biodiesel) is called transesterification. The vegetable oil is made up of 20% glycerine.

Transesterification involves taking the triglyceride molecule or complex fatty acids, removing the glycerol and creating an alcohol ester.

Triglycerides are reacted with an alcohol such as methanol, to give methyl esters of fatty acids and glycerol. This can be carried out in the school laboratory by mixing methanol with sodium hydroxide to make sodium methoxide, which is then mixed with vegetable oil. Glycerol remains as a by-product at the bottom when the mixture has settled and the biodiesel is left at the top, which can be washed and filtered.

Although, this reaction is not part of the LC Chemistry syllabus, this reaction is very similar to the saponification reaction, which is on the current Chemistry syllabus.

References:

Cosandey, M. (2006), 'Principal of the Internal Combustion Engine', [online] available:

http://sevelin44.educanet2.ch/chimie.cosandey/chem.exp/ [accessed 9 July 2012].
Denby, D, Otter, C & Stephenson, K. (2008), *Chemical Storylines,* University of York, Pearson Education Ltd.

DES (1999). Leaving Certificate Chemistry Syllabus. E. Science. Dublin, Government Publications.

O' Dwyer, A. and Childs, P. E. (2012) Introducing Isomers for Leaving Certificate Organic Chemistry', *Chemistry in Action!,* 98, 16-23.

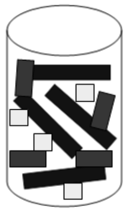
NOTE: If you want to get an electronic copy of this article and the pupil handouts, please email anne.m.odwyer@ul.ie.

A molecular model kit was designed to accompany the *Organic Chemistry in Action*! course, and you can order sets of this kit at €25 (plus p&p) from the authors.

However, you can buy molecular model kits from most laboratory suppliers and we recommend the ones made by Molymod™.

ACTIVITY 1: *Separating a mixture of Hydrocarbons*

The beaker of the hydrocarbon mixture given by your teacher is composed of three different hydrocarbons. The diagram of the beaker and the code below illustrates the mixture of hydrocarbons.



= Longest Hydrocarbon (20-40 carbon chain)

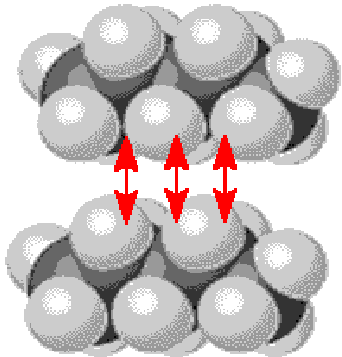
= Hydrocarbon (19 carbon chain)

= Shortest Hydrocarbon (10 carbon chain)

Mixture of Hydrocarbons provided by your teacher:

Component 1: Boiling Point = _____° C.
Component 2: Boiling Point = _____° C.
Component 3: Boiling Point = _____° C.

Interactions between electron clouds increases with larger surface. There are more electron-electron interactions.



Given that your mixture is made up of three different hydrocarbons (of different chain length, and different molecular mass), which of the components has the highest boiling point?

How does the length of the carbon chain affect the boiling point?

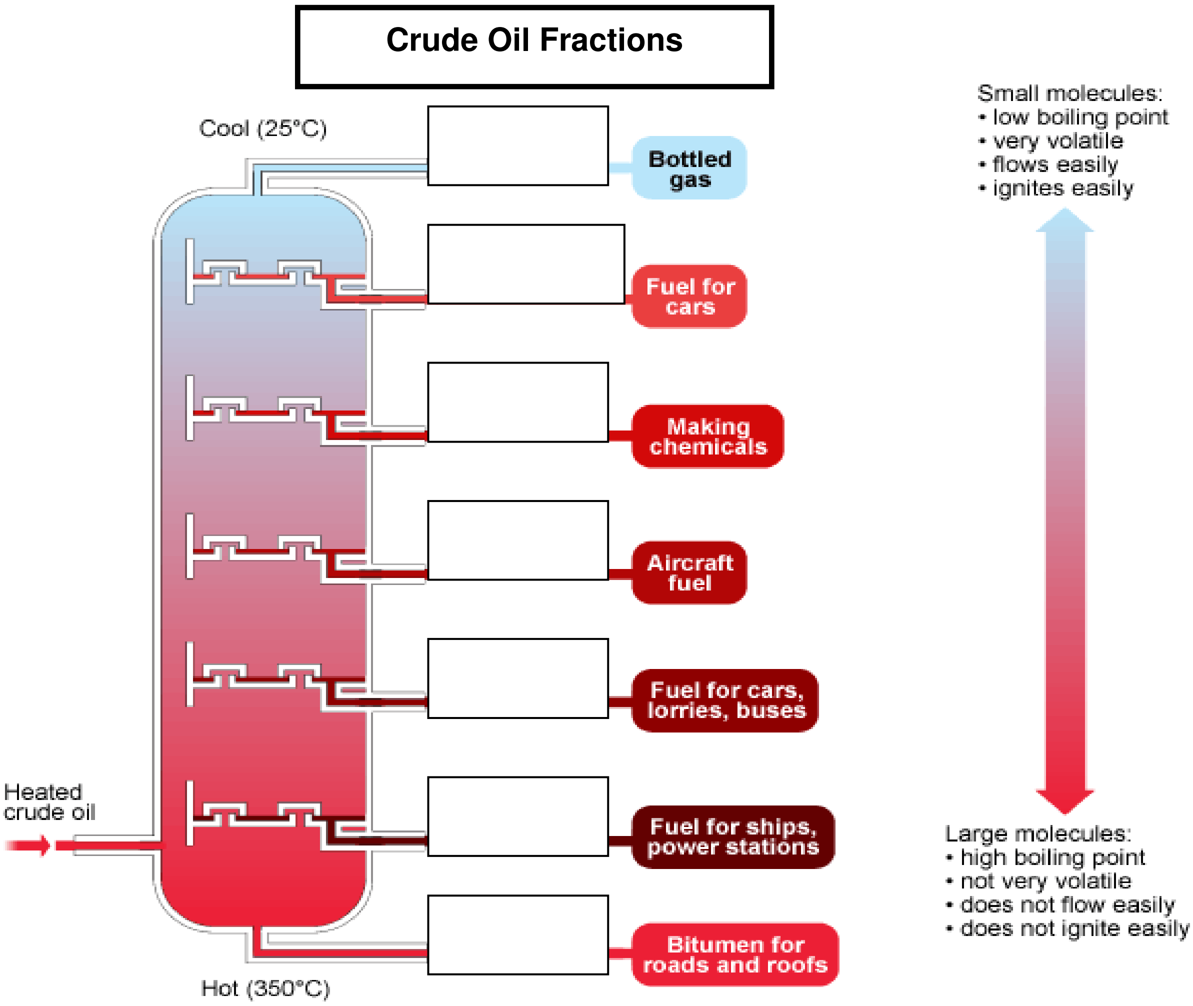
Make a list of the apparatus necessary to separate the three given hydrocarbons.
Make a plan of how will carry out this procedure.
Show this plan to your teacher before you begin.

Safety Note

- Always wear appropriate Personal Protective Equipment when carrying out an activity in the laboratory.
- Adhere to the safety rules outlined by your teacher.
- Never leave a lighting Bunsen burner unattended.
- **Caution:** hydrocarbons are highly flammable!

Use the information given in this table to determine at which tray in the fractioning column each of the crude oil products will be distilled.

Crude Oil Fraction	Molecular Mass (length of carbon chain)
Refinery Gas	C_1 to C_4
Residue	C_{70} upwards
Petrol	C_5 to C_{12}
Kerosene	C_{12} to C_{16}
Naphtha	C_{19} to C_{29}
Fuel Oil	C_{30} to C_{40}
Diesel Oil	C_{13} to C_{20}



Hydrocarbons which are gases at room temperature contain ____________ molecules.

Hydrocarbons which are solid at room temperature contain _____________ molecules.

Hydrocarbons with short molecules have _____________ boiling points.

Hydrocarbons with long molecules have ______________ boiling points.

Why?

ACTIVITY 2: *Factors affecting Octane Rating*

Knocking
Sometimes in the internal combustion engine, the petrol-air mixture explodes as it is compressed by the piston before being ignited by the spark plug.
This causes a knocking noise in the engine and affects its smooth running.

Octane Number
The Octane Number of a fuel is a tendency of the fuel to resist knocking.

An Octane Number of 97 indicates high quality petrol.
This means that is as efficient as a fuel made from 97% 2,2,4-trimehtylpentane and 3% heptane.
What would 89 Octane petrol be made from?

Petrol is composed of a mixture of hydrocarbons with chain lengths of 5-10 carbons.

Alkane	Octane Number
Heptane	0
Hexane	25
Pentane	62
3-methylhexane	65
2-methylpentane	73
3-methylpentane	75
2,3-dimethylpentane	91
2-methylbutane	93
Butane	94
2-methylpropane	>100

Use the information given in this table and answer the questions below:

1. Write out the molecular formula for each of the alkanes.
2. Draw the 2-D Structural formula for each of the alkanes.
3. Identify which of the alkanes are structural isomers of each other.
4. Classify each of the alkanes as:
   - **S**: Straight-chained.
   - **B**: Branched.
   - **M:** Multiple-branched chain.

   (Use the bolded letters to identify each)
5. Plot a graph showing the octane number of the alkane against the number of carbon atoms in the molecule.
6. Label each point on the graph with S, B, and M appropriately.
7. What conclusions can you read from your graph?
   a. How does chain length affect Octane Number?
   b. How does branching effect Octane Number?
8. What significance has all of this for petrol blending?

ACTIVITY 3: *Improving Octane Rating*

(You will need to use the reference table of Octane Numbers provided by your teacher)
Petrol is composed of hydrocarbons ranging in size from 5 carbon to 10 carbon chains. (C_5-C_{10}).

Materials required (per group of pupils)

- 15 (4-hole) carbon atoms
- 36 hydrogen atoms.
- 48 bond linkages

1. ISOMERISATION:

Procedure **A:**

1. Given the names of the compounds listed in the table, write the molecular formula for the straight chained alkanes in the space in the table.
2. Make the 3-D structure of pentane using the molecular models available.
3. Draw the 2-D structural formula of the pentane you have made:

Straight Chain Alkanes	Molecular Formula
Pentane	
Hexane	
Heptane	
Octane	
Nonane	
Decane	

Octane Number for Pentane = ________

4. How can the Octane Number of this pentane molecule be increased?

   ____

5. Use another 5 carbon atoms and 12 hydrogen atoms to build another hydrocarbon with a higher Octane Number.
6. Draw and name your new hydrocarbon here:

Octane Number for ___________________________________= _____

7. Is there any other possible hydrocarbon that can be made using the same number of carbon atoms (5) and hydrogen atoms (12)?
8. Draw and name a third possible hydrocarbon here:

Octane Number for ______________________________________= _____

What is the structural relationship between the three structures of C_5H_{12} which you have made?

____

Why are the octane numbers different for each?
Explain with reference to the structure of each.

Organic Chemistry in Action!

2. REFORMING:

As well as shorter chains and branched hydrocarbons having a higher octane number, research has also found that cyclic hydrocarbons have higher Octane Numbers.
This means that they have a greater tendency to resist knocking than straight chain hydrocarbons.
A cyclic hydrocarbon is a hydrocarbon with a ring structure e.g. cyclohexane, as opposed to a straight or branched open chain.

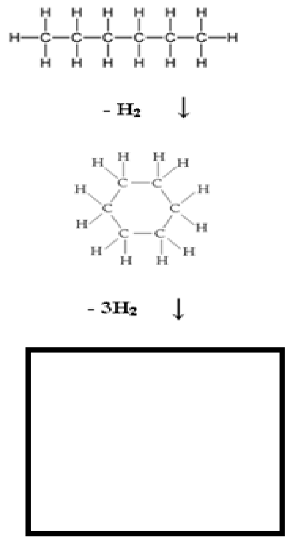
Reforming
Reforming is the name given to the process where straight open hydrocarbon chains are converted to cyclic hydrocarbons.
This process is also called dehydrocyclisation.

Procedure:

1. Write the molecular formula for hexane: ______________
2. Octane Number of hexane = __________
3. Make the 3-D structure of straight chain hexane.
4. Draw the 2-D structural formula of the straight hexane chain:

5. What do you need to do to change this into a cyclic compound?
   ____
6. Modify your molecular model to make it into a 6 carbon cyclic hydrocarbon compound.
7. Draw the 2-D structural formula of the new cyclic compound:

8. What is the molecular formula of the new hydrocarbon? ________
9. Name this new cyclic hydrocarbon: _______________________



If you were to take three more hydrogen molecules (H_2) from the cyclic compound formed, what new compound would be formed?

Name this new molecule and comment on its Octane Number:
____
____

Reforming is also called DEHYDROCYCLISATION.
Can you explain why reforming is described as de-hydro-cylisation?

ORGANIC CHEMISTRY IN ACTION!

3. **CATALYTIC CRACKING:**

Catalytic Cracking

Catalytic Cracking is the breaking down of long-chain hydrocarbon molecules into short-chain molecules for which there is more demand.

Important

There isn't any single unique reaction happening in catalytic cracking. The hydrocarbon molecules are broken up in a fairly random way to produce mixtures of smaller hydrocarbons, some of which have carbon-carbon double bonds.
Liquid paraffin is one of the longer straight chain alkanes often used in catalytic cracking.

Procedure:

1. Paraffin is an alkane. Recall the general formula for alkanes: ____________________.
2. If paraffin has 16 carbon atoms, what will its molecular formula be? _______________________.
3. Build a straight chain alkane found in liquid paraffin.
4. Draw the structural formula of the straight chain here:

5. Now, imagine this long hydrocarbon chain is heated in the presence of a catalyst. Can you 'crack' it into three possible products?
   a. Draw the structural formula of each product.
   b. Write the molecular formula of each product.
   c. Name each product.

Rules:
1. You cannot lose any of your hydrogen of carbon atoms in the process of cracking.
2. You must have the same number of atoms at the end.
3. All of the carbon atoms must have a valency of 4.

6. Compare your three products with your starting hydrocarbon:
   a. Is there any difference in saturation?
   b. Is there any difference in the type of hydrocarbon (alkane / alkene / alkyne)?

____

____

7. Now compare your three products with the products formed by another group of pupils from the same starting material. What do you observe?
   a. What is the same about the products?
   b. What is different about the products?

8. Compare the size of the hydrocarbon chain of your starting material and your products. What state of matter would you expect each of these to exist as at room temperature? Explain why.

____

____

SuBATOMIC

Supporting Better Activities To Overcome Misconceptions In Chemistry

SuBATOMIC - Calling All Science Teachers!

Muireann Sheehan

Chemistry Education Research Group, Department of Chemical and Environmental Sciences and the National Centre for Excellence for Mathematics and Science, University of Limerick

muireann.sheehan@ul.ie

Mind the gap!

The large gap between research and practice is something that I often hear bemoaned. Science education researchers can't understand why science teachers don't read more of their work and teachers can't understand why research doesn't have a more practical focus; after all, teaching is both a practical and an intellectual endeavour.

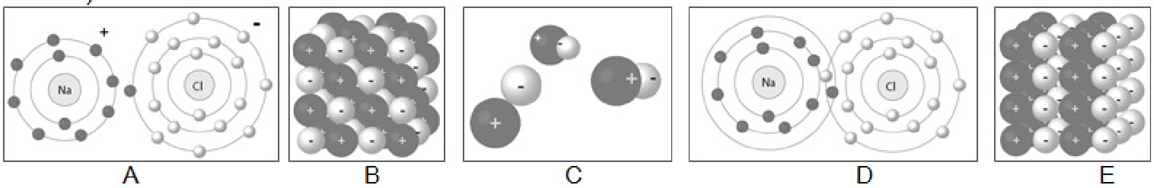
I am attempting to bridge the gap between research and practice for student science teachers in the area of chemistry misconceptions. A website is currently under development, called SuBATOMIC (Supporting Better Activities To Overcome Misconceptions In Chemistry). The website is focused on, but not limited to, activities which can help student science teachers to address the misconceptions of their pupils on the Junior Certificate programme and I am looking for teachers to assist in any of the following areas:

- Review the content of the SuBATOMIC website to assess its usefulness, accuracy and practicality for student science teachers and potentially in-service teachers.
- Try out some of the teaching activities suggested on the website, rate them and suggest alterations.
- Suggest activities which you have found useful in revealing and/or addressing pupils' misconceptions.
- Write a short article aimed at student science teachers which describes a strategy or activity which you have found useful or simply which offers them advice on any teaching issues.

How Does Your Participation Benefit Student Science Teachers?

The creation of the SuBATOMIC website is part of a larger project, the first part of which investigated the chemistry misconceptions among student science teachers. A questionnaire was created to assess which of the most common misconceptions in chemistry were held by student science teachers. The questionnaire was composed of 20 questions, mostly multiple-choice questions, some of which included particle images such as the one below. The majority of the questions were focused on very basic chemistry concepts in the areas of the particulate nature of matter, stoichiometry and bonding.

11. Which of the following best represents the **ionic compound** sodium chloride (NaCl)? (**Circle the correct answer**)



467 student science teachers completed the questionnaire. This group included those on consecutive science teacher training programmes (a science degree followed by the professional diploma in education) and concurrent science teacher training programmes (science, pedagogy and education studied at the same time in a degree course). The group included student science teachers studying in both Northern Ireland and the Republic of Ireland.

Student science teachers were found to have a very poor understanding of basic chemistry concepts (with an average score of 37.4%.). One might have expected that those who were more advanced in their concurrent programmes and particularly those on consecutive programmes, given that they have studied more science, would display a better understanding of basic chemistry concepts but this was not the case! Comparing those with a specialism in chemistry with specialisms in other science areas proved very disappointing, as those with chemistry were only likely to answer one more question correctly than their peers.

A sample of some of the more common misconceptions found among the 467 student science teachers were:

- Covalent bonds break on boiling (20% of the student science teachers believed this)
- Breaking covalent bonds releases energy (32% of student science teachers)
- A single atom of sulphur has the melting point (and other macroscopic properties) of a bulk sample of sulphur (32%)
- $2SO_3$ means the same thing as S_2O_6 (38%).

To summarise the findings of this part of the project in a sentence, I would have to say that "studying more chemistry does not lead to understanding more chemistry".

"studying more chemistry does not lead to understanding more chemistry"

Some of you may be surprised at this but I am not surprised. I trained as a chemistry and physics teacher in a concurrent science teacher training programme and I decided to start this project precisely because I knew I didn't understand all the things I was supposed to understand when I finished my degree!

The SuBATOMIC website will provide student science teachers with a place to find out about the most common misconceptions they might come across in the chemistry section of the Junior Certificate science syllabus. They will be able to troubleshoot their own understanding in a page called 'Check Your Understanding'. This, incidentally, is how I have improved my own knowledge of basic chemistry concepts; by reading about a misconception and then trying to figure out, using books and whatever else I could get my hands on, exactly why this misconception was wrong… because the misconception would normally seem perfectly logical to me! The website will also attempt to bridge the gap between the research about targeting misconceptions and practice in the classroom by informing student teachers about the 'nuts and bolts' of a research idea and providing examples of activities in which this research idea is in action.

So much of this website's success in helping student science teachers to reflect on their own misconceptions and target their pupils' misconceptions depends on being able to reliably convert research into practice. That's where you come in! Your participation can improve the website and give student science teachers the confidence they need to try to implement a little research-based practice.

How Could Your Participation Benefit You?

Many of the activities and ideas included in the site may be familiar to you from your everyday practice. However, some might inspire you to try something new in the classroom or to reflect on why different activities are successful or unsuccessful with different groups of pupils. The website will also link to a Facebook page for student science teachers and in-service teachers, allowing an exchange of ideas to occur beyond the confines of classroom, staffroom or even geographical location.

In this way the SuBATOMIC website could prove to be a symbiotic relationship (to borrow a biology term) between student science teachers, teachers and science education research and researchers.

How to Get Involved

If you wish to get involved in any aspect of this project please contact me at muireann.sheehan@ul.ie. I look forward to hearing from you!

Note: *This activity is part of the PhD research by Muireann Sheehan at the University of Limerick, supervised by Dr Peter E. Childs, as part of the work of the Chemistry Education Research Group and the National Centre for Excellence in Mathematics and Science Teaching and Learning. The project is funded by the Irish Research Council.*

IRISH RESEARCH COUNCIL
An Chomhairle um Thaighde in Éirinn

□

CheMiscellany 1

Kabooom!

"V. ROGERS" TEXVR@leeds.ac.uk
This was a story told to us by our chemistry master at school. A female student wished to make some potassium hydroxide solution (aqueous) and decided to throw a large lump of potassium into a bucket of water. Her professor observed what she was about to do, out of the corner of his eye and hurried towards her, and after confirming this was what she was intending to do, asked her first to stir the water in the bucket for five minutes before adding the potassium. She was puzzled and ran after him to ask the purpose of this action.
'It will give me time to get away' said the professor.

Chemical: A substance that

1) An organic chemist turns into a foul odour;
2) an analytical chemist turns into a procedure;
3) a physical chemist turns into a straight line;
4) a biochemist turns into a helix;
5) a chemical engineer turns into a profit.

Definitions

Organic chemistry is the chemistry of carbon compounds.
Biochemistry is the study of carbon compounds that crawl.
Mike Adams

Chemical limerick

There once was a girl named Irene
Who lived on distilled kerosene
But she started absorbin'
A new hydrocarbon
And since then has never benzene.

Bumper stickers:

Every dipole has its moment.

Free radicals have revolutionized chemistry.

Got mole problems? Call Avogadro at 602-1023.

It takes alkynes to make a world.
(see also p. 48)

The Instrument Makers No. 3:
Abu Bakr Mohamnad ibn Zakariva Razi 865 – 925

Adrian J. Ryder
tutorajr@gmail.com

Rome as a political force had been in decline from the fourth century CE (Common Era), with the dark ages of Europe beginning from the end of the seventh century. One of the factors affecting the Roman decline was the rise of Islam which came on the scene in 622 CE with Muhammed and his small band of followers undergoing the Hijria (migration) from Mecca to Medina. The years to come were to see the Egyptian provinces of Rome fall to the Islamic forces, completing Rome's demise as a major political force. While Rome and western Europe fell into the dark ages the new religion of Islam was flourishing; the period from 750 CE to 1258 CE being a truly golden age in the lands under Islamic influence. This age was abruptly ended in 1256 CE with the sack of Baghdad by the Mongol hoards. Somewhere between 100,000 and a million people were put to death and the city was totally burnt, including the magnificent libraries. The city was to remain deserted and in ruins for centuries.

The subject of this essay comes onto the scene about midway through this Golden Age in the year 865 CE. Abu Bakr Mohamnad ibn Zakariva Razi arrives at a time when the art of Chinese paper making is established (introduced mid 8th century), taking over from the expensive hide (vellum) and papyrus used previously. The introduction of paper led to the widespread development of libraries, public and private, and so to the dissemination of information. Further the introduction of the 'arabic' numerals (1, 2, 3..) and the zero, which had replaced the cumbersome Roman numerals (I, I, III, IV …), also occurred about the same time. A common language, Arabic, was used throughout the region and the promotion of public education saw scientific study widely used and fostered by the time our subject appears.

When, in later years, the Islam works appeared in Europe Abu Bakr Mohamnad ibn Zakariva Razi's name was shortened to 'Rhazes' and it is this form that is used in this essay for convenience.

A portrait of Rhazes in his prime

Rhazes was born about 865 CE, in the city of Rai in Persia (now Iran), not far from Tehran. Who Rhazes parents were is nowhere recorded, nor is there any record of any siblings. Further there is no record of his being married or having children. He is supposed to have been proficient on the flute and to have had a good singing voice, but these were abandoned on his uptake of serious studies in medicine, chemistry (alchemy) and philosophy at about the age of thirty years. His uptake of medicine has been ascribed to the sufferings of patients he witnessed on a visit to a hospital and his desire to help those undergoing the hardships of disease.

He studied medicine under a Jewish physician, Ali ibn Sah al-Tabari, who was an adept of Greek, Persian and Hindu medicine and Rhazes began his medical practice in his home town, where his skill was quickly recognized and he was appointed director of the first Royal Hospital there. After some years there Rhazes moved to Baghdad in about 907 CE to take charge of its famous Muqtadari Hospital and it is here that he was to gather the main part of his clinical observations. Apart from his work at the hospital, Rhazes was also the Court Physician and among the 'perks' of the job was the opportunity to travel with the

Court to cities under its rule, among them Cordova in Spain and Jerusalem.

His travels brought him in contact with the most eminent physicians of the time and he was quick to see the use of new ideas, such as the use of animal gut for sutures and plaster of Paris for casts supporting broken bones.

Rhazes became a prolific writer, producing over two hundred books in all. Translations of some thirty-six of these have survived to this day. One of these, a twenty-five volume work on surgical methods and medicine, was translated in 1279 into Latin under the title *Liber Continens*. Another of his works was directed at the traveller and for home use, where the man in the street could look up the treatments for common ailments. These were, in the main, simple remedies, but included various mercurial compounds, and supplements for the diet. Rhazes warned against the dangers of complexity in preparations.

He discovered allergic asthma and wrote a text on allergy and immunology as a result. He wrote the first accurate account of measles and smallpox and noted that those who survived the smallpox did not suffer from it again.

Rhazes was aware that he could not deal with all the patients who attended the hospital himself and adopted a method where patients were first seen by those studying to become physicians. Those patients whose diseases were beyond the scope of these novices, were passed on to a higher trained group, with Rhazes only seeing those whose diseases were beyond the diagnostic endeavours of his subordinates.

He ensured that the treatment of diseases was available to all, the poor as well as the rich, and gave so much of his own monies to feed and nurse the poor patients that he died in poverty. By the time he died, in the year 925 CE, he had been blind for a number of years, having suffered from cataracts for many years and he had refused to have anyone operate on them.

In the picture below Rhazes is seen working in his pharmacy. Doctors of the time were used to dispensing their own concoctions. Rhazes made long studies of the medicines in use, not only in Persia, but also in other lands. He contributed greatly to pharmacy by his compilations of these medicines, which were widely disseminated by his students and disciples. In the picture one can make out various pieces of apparatus, developed by him, which are still in use today. Among these are to be found flasks, mortars, phials, spatulas and carboys. Just under the window appear to be two beaker-like pieces of glassware.

Rhazes and assistant in his laboratory

Rhazes lived at the beginning of the modern chemistry era. He rejected the fire, air, earth and water view of the world but still thought that all the elements were derived from two substances: sulphur and mercury. He wrote a manual that classified the known chemicals of the time and gave detailed instruction on their preparations. He made an effort to classify all known substances, basically under the headings of animal, vegetable and mineral origins.

One could regard him as the last of the alchemists for he rejected the use of spells and magic, while still holding to the possibility of transmutation of the elements, as he felt that gold and silver should be derivable from baser metals.

An expert at experimentation, Rhazes developed the first distillation apparatus and for this alone he merits this essay. His apparatus was so effective that gave the world the first preparation of sulphuric acid by the dry distillation of vitriol (iron(II) sulphate).

Vitriol, $FeSO_4$, on heating in air changes to $Fe_2(SO_4)_3$ and this, on dry distillation, is converted to $Fe_2O_3 + 3SO_3$. The SO_3, on passing into water, reacts to give H_2SO_4.

$$SO_3 + H_2O \rightarrow H_2SO_4.$$

With the same apparatus Rhazes was the first to prepare pure alcohol (ethanol). He went on to use the apparatus to distill/refine petroleum and also produced kerosene, which was used as lamp oil and in our era is used as jet fuel.

He gave lists of apparatus in use at the time, both for metallurgy and pharmacy/chemistry, many of which he had developed from more primitive forms. Many of these were still in use in the twentieth century.

Instruments used for metallurgy included the blacksmith's hearth, bellows, crucible, tongs (tongue or ladle), macerator, stirring rod, cutter, grinder (pestle), file, shears, descensory and semi-cylindrical iron mould.

Some of the instruments used in the attempts at transmutation and various parts of the distilling apparatus were the retort, alembic, shallow iron pan, potter's kiln and blowers, large oven, cylindrical stove, glass cups, flasks, phials, beakers, glass funnel, crucible, alundel, heating lamps, mortar, cauldron, hair-cloth, sand- and water-baths, sieve, flat stone mortar and chafing-dish.

While he spent a great deal of time in writing he was very much aware of the shortcomings of the written word, maintaining that all that which is to be found in books is not as valuable as the experience of a single wise doctor.

In later years Rhazes developed cataracts in both eyes which finally left him totally blind. He refused to allow his eyes to be treated and died in poverty on the 27th of October 925 CE.

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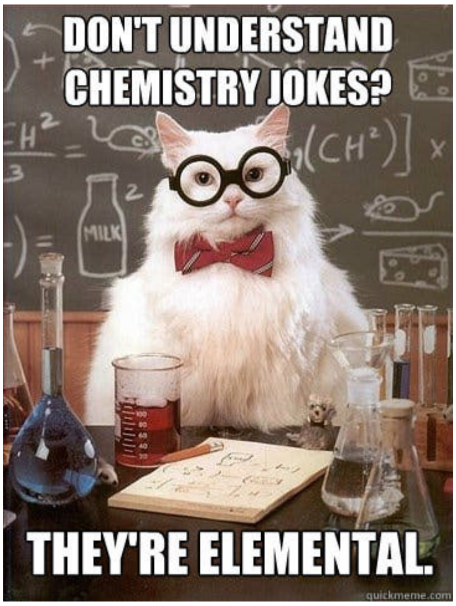
CheMiscellany 2

"What are the three most important rules of the chemist?"
This I knew from Ben. "Label clearly. Measure twice. Eat elsewhere."

Patrick Rothfuss *The name of the wind*

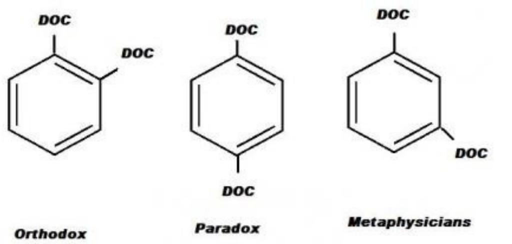
What's in a name?

"There was something ghost-like and insubstantial about gases to these early chemists. They called liquids that turned into gases easily, "spirits." Methyl alcohol, they called "wood spirit"; ethyl alcohol, "wine spirit." Even today, alcoholic beverages are frequently referred to as "spirits." (Modern Arabs, from whose language the word "alcohol" was taken, call ethyl alcohol "spirit" from the English. This is a queer exchange.)"
Isaac Asimov



See http://chemistry.about.com/od/chemistryjokes/ig/Chemistry-Cat/ for more chemistry cats!

Organic chemistry made simple:



The Problem of Language in Science Education

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Introduction: the language problem in teaching and learning science

The language of science is a problem that students face in both second and third level education. Wellington and Osborne (2001) claimed that *"language is a major barrier (if not the major barrier) to most students in learning science"* (p. 2). Science has its own language and difficulties and acquiring and understanding this new language act as a barrier for many students. However, research has indicated that the problem lies not so much in the technical language of science (e.g. isotope), but in the vocabulary and usage of normal English in a science context (e.g. solution) (Cassels & Johnstone, 1980, 1985). Students and teachers see familiar words and phrases, which they both 'understand', but the assumption that both understandings are identical is just not tenable (Barber, 1962; Sager *et al.,* 1980; Kennedy & Bolitho, 1984).

> *Are you and your pupils talking the same language? Is there a problem and what are the consequences for learning in science?*

The disparities between everyday language and scientific terminology means that every student of science, regardless of them being a native or non-native English speakers, are learning a new and complicated language when learning science (Garraway, 1994). Consequently, the multi-faceted nature of scientific language is a problem for native and non-native English speakers, although it is intensified for the latter group (Childs and O'Farrell, 2003) and is enhanced in mixed-ability teaching. This is very pertinent to Ireland's current school population, which since the start of the Celtic tiger era has become increasingly more culturally and linguistically diverse (Lee, 2001; NCCA, 2006), a trend which continues to persist according to a survey conducted by *The Irish Times* (30 March 2012, p. 62). However, to-date in Ireland, little research has been conducted into the problems caused by language in the teaching and learning of science in second-level schools.

Improving the quality of second-level science education is vital to producing Ireland's 'knowledge economy' and scientifically-literate citizens. The old proverb says that given a fish, one can eat for a day; taught to catch fish, one can eat for a lifetime. We cannot improve second-level science education without addressing the underlying problem of scientific language, in its different facets, as language is a major, but largely unrecognised, barrier to understanding and enjoying science in the Irish junior cycle. Thus action is needed in order to improve the understanding of science in the junior cycle and hence the take-up of science at senior cycle and consequently at third-level. Helping students to master the language of science enables them to become fishers themselves, with a lifetime thirst for knowledge and the skills to seek and learn on their own (Staver, 2007). As science teachers we are the central agents to achieving this goal: accordingly, we need first to be aware of the difficulties students are presented with when learning science and second, equipped with teaching strategies and methodologies to alleviate and deal with students' problems.

This research project

I would like to take this opportunity to introduce myself. I am a research PhD student in the Department of Chemical and Environmental Sciences at the University of Limerick, researching the area of the use of language in science teaching and learning. The title of my research is *"An investigation of the role of* *language in the teaching and learning of science at second-level in Ireland".*

To date in Ireland, little research has been conducted into the role which scientific language plays in the teaching and learning of science at second- and third-level education. It is a problem that has largely gone unrecognised. The hypothesis underpinning this project is that the acquisition of scientific language is a major problem in the teaching and learning of science at second- and third- level education in Ireland, and one of the factors that turns students off science in the junior cycle. This project aims to investigate the validity and severity of this hypothesis through identifying the specific problem areas of language in science teaching and learning in Irish schools. Furthermore, this project aims to develop and evaluate teaching and learning strategies and materials to assist in making the teaching and learning of science at second- and introductory third-level education more effective, and to reduce the rate of attrition from science at both these levels. However, the initial work will be done with students taking science in the junior cycle.

Your participation

The next phase of the research is the Intervention Programme, which aims to assess the effectiveness of the developed teaching and learning strategies.

Participation in this research would require the following:

- Distribution of a pre-test to a group(s) of students, collecting and returning them to the researcher in the stamped addressed envelope provided.
- Attendance at an information session on how the Intervention Programme should be used in your teaching (this session can be conducted to suit you, either in school or in UL).
- Teaching 3 topics in the Junior Science Syllabus using the new strategies, for which you will receive all the resources and assistance needed. (These resources can then be adapted and used again to teach all topics).
- Re-testing the same students after teaching using the new strategies, collecting and returning it to the researcher in the stamped addressed envelope provided.

I will be contactable throughout the intervention programme if assistance is needed at the email address below.

Please contact me if you are interested in participating in the research. Thank you for taking the time to consider participating in the study. If you have further questions fell free to contact me, Marie Ryan (Marie.C.Ryan@ul.ie).

References

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Marie Ryan is a postgraduate student working under the supervision of D. Peter E. Childs at the University of Limerick and this intervention is part of her PhD project.

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Conference Reports

Eurovariety 2013 *'Smarter teaching, better learning'*

3-5 July
University of Limerick www.eurovariety2013.ul.ie

The 5th European Variety in Chemistry Education (EViCE) was held at the University of Limerick from 35 July 2013. Nearly 80 people attended from around Europe and further afield, mostly university lecturers in chemistry or science education lecturers preparing second-level chemistry teachers. It was encouraging to see a number of postgraduate students. The programme consisted of 5 plenary lectures, 4 workshops, 41 oral papers and 8 posters. There was a lively discussion at the poster reception and then at each coffee break. It was encouraging to see how many people stayed right to the end of the conference and the timing was designed to allow many people to arrive on the first day and leave after the final session. The conference was opened by welcome addresses from Professor Don Barry (President, UL), Pat Hobbs (President, Institute of Chemistry of Ireland), Professor Ilka Parchmann (Chair, EuCheMS, Division of Chemical Education) and Professor Kieran Hodnett (Dean, Faculty of Science and Engineering,UL).

The organisers were grateful for the sponsors who helped underwrite the costs of the conference and helped us keep the registration fee low (which included registration, meals and accommodation as a package). The major sponsors were: the Institute of Chemistry of Ireland; the RSCs Tertiary Education Group, Chemistry Education Research Group and Education Division Ireland Region, Merck Sharp and Dohme, and Aughinish Rusal. In addition there were a number of other industrial sponsors.

List of plenary lectures:

'Teaching college chemistry: context, collaboration and communication' Reiner Glaser (USA)

'Enhancing the Student Experience in Undergraduate Chemistry' David McGarvey (UK)

'Translating university chemistry for the classroom' Sabine Streller (Germany)

'Learning chemistry through inquiry' Natalie Rowley (UK)

'The more we do, the less they do..? Effective use of technology in chemistry education', Michael Seery (Ireland)

List of workshops:

' Wikis – what they are and how they are used to facilitate and assess group assignment ', Claire McDonnell

'Getting started in pedagogic research', Tina Overton

'Publishing in chemical education – research and popular', Karen Ogilvie and Michael Seery

'Promotion and outreach activities ', Sylvia Draper and Tim Harrison

The program was very full (and is available on the website), as the conference only lasted for two full days (spread over three days). However, everything went smoothly and the proximity of the rooms made it easy for participants to move from one session to another. The number and quality of the talks was very encouraging and there were a good number of first time attendees at Eurovariety. There was some very positive feedback after the conference and the organisers hope that everyone took back something useful to their home institutions. The next Eurovariety conference will be held in Estonia in 2015.

Photoessay on Eurovariety 2013

Poster session and drinks reception

The barbecue and Irish music in the Stables

Participants networking over coffee and pastries

The banquet at the Lakeside Hotel, Killaloe

The workshop on using Wikis led by Claire McDonnell

The conference participants at Killaloe for the conference banquet (see also front cover)

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7th Chemistry Demonstration Workshop

24-28th June

University of Limerick

The 7th annual Chemistry Demonstration Workshop ran from lunchtime on Monday 24th June to lunchtime 28th June. The main tutors were Dr Peter Davern (CES Department) and Marie Ryan (Postgrad, CES Department). Dr Peter Childs took a back seat this year, although he was involved on some days, as he was organising the Eurovariety 2013 conference the following week.

The Chemistry Demonstration Workshops have become an annual event at UL and over 70 teachers and students have been trained over the past 7 years.

The students sponsored by Pharmachemical Ireland prepare to be amazed.

The workshop attracted 5 teachers and 6 newly qualified science education students. In addition to the programme of talks and demonstration sessions, there was also a session from PDST on using ICT in teaching chemistry, facilitated by Peter Jackson, and also a session on simple physics demonstrations run by Paul Nugent and David Kiernan (IOP).

After trying a series of set chemistry demonstrations, participants are then free to choose and try out their own demonstrations, taken from a wide range of printed and internet resources, subject to health and safety clearance! Every participant gets to try out and master 20-40 demonstrations during the workshop, which can be taken back to school and put to immediate use in September. In addition, they have to work with one or more people to design, prepare and put on a science magic show at the end of the week. This gives participants a chance to show off their new skills, to gain more confidence by practising the demonstrations, and also the experience of putting on their own science magic show. The hope is that they will take these new skills back to school and put them to use in their day-to-day teaching, and in promoting science at open days or during science week.

The workshop is residential, as the social dimension of working and eating together is important, as well as the Wednesday evening social night in the Scholars. The workshop is subsidised and costs participants only €100 for 4 nights B&B and all meals, plus tuition and materials. The science education students are sponsored fully by Pharmachemical Ireland.

Thanks for sponsorship are due to the Chemical and Environmental Sciences Department, University of Limerick; the Professional Development Service for Teachers (PDST); Pharmachemical Ireland; and the Institute of Physics (IOP). Unfortunately the Royal Dublin Society (RDS) is no longer a sponsor, as they are now focusing their efforts on primary science.

The week goes past very quickly, as everyone works hard from 9.30 to 5.30 for three days, plus two half days, and there is a lot of laughter and fun. The workshop is intensive and fairly long, because it takes time to change behaviour and build up confidence and skills. Many of the demonstrations done in the workshop are well-known but may not be familiar to all the teachers or students, and many of them are done on the RSCs Courses for Non-Specialists. However, chemistry teachers also need the opportunity to brush up their skills and add to their repertoire of demonstrations, and to gain additional confidence to try out new ideas for themselves. It is our hope as organisers that the workshops will equip teachers and student teachers to able to fish for themselves, rather than just passively being given fish (to use a metaphor), and will become self-starters in the classroom, who will be able to translate ideas from books and the internet into their own classroom practice. There is a big emphasis on safety in the workshop, and we also want teachers to be more aware of safety in the classroom when doing demonstrations, so that they know and will take all necessary precautions in their own laboratories.

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Diary

2013

10th ESERA,
2-7 September
Nicosia, Cyprus
http://www.esera2013.org.cy/nqcontent.cfm?a_id=1
info@esera2013.org.cy

ICASE 4th World Conference on Science and Technology Education
29 September – 3 October
Borneo, Malaysia
http://worldste2013.org/

32nd ChemEd-Ireland
Sat. October 19
Limerick Institute of Technology, Limerick
Marie.walsh@lit.ie

N-W IOSTE Mini-Symposium
25-26 October
'Science Education Research'
Church of Ireland College of Education, Dublin
okelly@cice.ie

1st. African Conference on Chemical Education (ACRICE-1)
"Chemical Education for the Human Development in Africa"
5-7 December 2013
Addis Ababa, Ethiopia
http://www.faschem.org/index.php?option=com_content&task=view&id=29

2014

52nd ISTA Conference
11-13th April 2014
NUI Galway
www.ista.ie

3rd New Perspectives on Science Education
20-22 March 2014
Florence, Italy
http://conference.pixel-online.net/npse2014/

12th ECRICE 2014
"New Trends in Research-based Chemistry Education"
7-10 July 2014
Jyväskylä University, Finland
www.jyu.fi/kemia/en/research/ecrice2014//

International Conference on Chemistry Education 2014 TORONTO, CANADA

23rd ICCE
13-18 July 2014
University of Toronto,
Toronto, Canada
www.icce2014.org/

2014 Biennial Conference on Chemical Education
August 3-7, 2014
Grand Valley State University,
West Michigan, USA
http://www.bcce2014.org/

33rd ChemEd-Ireland
18th October 2014
DIT, Dublin
Claire.mcdonnell@dit.ie

If you know of any relevant conferences or events of interest to chemistry teachers, please send in details to:
peter.childs@ul.ie

Classical Chemical Quotes: #5

Marie Curie
(7/11/1867 - 4/7/1934)

"We must not forget that when radium was discovered no one knew that it would prove useful in hospitals. The work was one of pure science. And this is a proof that scientific work must not be considered from the point of view of the direct usefulness of it. It must be done for itself, for the beauty of science, and then there is always the chance that a scientific discovery may become like the radium a benefit for humanity."

Lecture at Vassar College, May 14, 1921

Information Page

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Limerick, IRELAND

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Contributions wanted!

Contributions are always welcome to *Chemistry in Action!* providing the material is of interest to second-level chemistry teachers. Articles, experiments or demonstrations, teaching tips, book and AV reviews etc. are all welcome.
Send one hardcopy + diagrams and a copy on disc (or by email as a Word document) when submitting material.
You can contact the editor by email at: **peter.childs@ul.ie**

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Internet version

Chemistry in Action! is in the process of being put on the Internet at URL:
http://www.ul.ie/~childsp
It is hoped to put back issues will be put on the Internet one year after publication. This is not yet fully operational and only issues 38 - 68 are now available. In time I hope that most back issues will eventually be available, 3 issues after publication.

At the same site you will also find the University of Limerick's science and technology magazine for schools, *ELEMENTS* and also information on SICICI, ChemEd-Ireland and other chemical education activities.

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Editorial correspondence

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Communications in writing/e-mail are preferred rather than phone calls!

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Peter.childs@ul.ie

In the next issue:

The next issue will be #100, marking 33 years of publication. Contributions are invited for this issue!

2013 LC Results