Contents #103

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

For subscription details etc. see inside back cover.

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Cover photo: Science buildings across the lake at Jyväskylä, Finland at ECRICE 2014, see p.53. (Photo: P.E Childs)

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Editorial #103

The summer of our discontent

This has been an interesting summer of conferences and industrial disputes! Both secondary teachers' unions, ASTI and TUI, have voted for industrial action over the failure of the Minister of Education (now Jan O'Sullivan) to respond to their concerns over the new Junior Cycle Student Award (JCSA), in particular in relation to assessment. This dispute had not been solved by the start of the new school year and science teachers were told to boycott any discussion of the new science specification, which was issued in October. This meant that a Junior Science Consultation meeting convened by the NCCA on October 14th was not attended by teachers or the ISTA! There is a real danger that the science specification will be finalised and sent out to schools without any meaningful input from science teachers. We hope to look at the new science specification in the next issue. In this issue we look at the proposed LC Chemistry course, with some critical comments from the Hyland Report (launched in April at the ISTA Conference in Galway), and views from John Daly (Convenor, ISTA Chemistry Sub-committee) and Michael Seery.

Managing the transition

One important issue is that the LC Chemistry specification (it is not a syllabus as it only contains outcomes) has been finalised before the junior science specification has been agreed. This is, of course, the wrong way round. There is less time in the proposed new junior science course (200 versus 240 hours) and the chemistry 'content' is very limited and manages to omit a mention of chemical bonding. This means that the already large gap in content between the junior and senior cycles, with respect to Chemistry, will now be even larger. This means that the LC Chemistry course needs to be designed with this in mind and needs to start at a lower level. If the new JCSA science course starts in 2015 (as proposed), then the students who take it would be starting their LC courses in 2018. The LC Chemistry course will need to be revised and matched to the new junior science course, to make the transition as smooth as possible.

The focus on process and skills at the expense of content and knowledge evident in both the junior science and LC Chemistry specifications, with their over-emphasis on outcomes at the expense of depth of treatment, is going to make the chemistry teacher's job more difficult. Students may know now more about the nature of science, which I think is a good thing, but they may have little chemical knowledge to apply these ideas to.

The problem of assessment

The other big issue is that of assessment and in particular the balance between school-based and external certification. Teachers, parents and employers are rightly concerned about this and a loss of credibility of the course and comparability across schools.

The assessment of practical work is a specific issue for science subjects and the experience of assessing practical work through Coursework A and B in the current Junior Certificate Science course does not give one much encouragement for the future. Fair, valid and reliable assessment of student's practical work, through coursework, projects or a practical examination, is not a trivial task and is fraught with problems. There is also the major problem of increased resources for practical work, if inquiry-based science teaching becomes the norm. Also the logistics and costs of running LC practical examinations for ~33,000 Biology students, ~ 8,500 Chemistry students and ~ 7,000 Physics students will be horrendous.

We hope to continue this discussion of both the junior science course and the LC Chemistry course in future issues. If you have any comments or views on either course, please send them in.

Peter E. Childs
Hon. Editor

Education News and Views

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

The Hyland Report

Concerns about the revised LC science courses and the lack of real response to their concerns from the NCCA led the ISTA Council to commission a report from Professor Áine Hyland. This report was launched at the ISTA conference in Galway in April. The ISTA press release on the report is given below.

ISTA Press Release

The proposed new Leaving Certificate Biology, Chemistry and Physics syllabi, which have recently been submitted by the NCCA to the Minister for Education and Skills for approval, have been criticised at the 52nd Annual Conference of the Irish Science Teachers' Association (ISTA). A report by a leading academic, launched at the conference, indicates that failure to act now means Ireland will be out of step with international good practice in syllabus design.

Professor Áine Hyland, Emeritus Professor of Education at UCC, presented the findings of a report entitled 'The design of Leaving Certificate science syllabi in Ireland: an international comparison' to a packed D'Arcy Thompson Lecture Theatre at NUIG on Saturday 12th April. Professor Hyland was appointed by ISTA as an independent external expert to report on international best practice in syllabus design. While highlighting the vision shared by the education partners – that Ireland must provide a high quality, up-to-date curriculum for its young people and that the Leaving Certificate must maintain its highly-respected national and international status - the report concludes that the syllabi as recently revised, do not conform to international best practice. (see attached summary and report for full background).

The commissioning of the 80-page report has its origins in the failure of the National Council of Curriculum and Assessment (NCCA) to address concerns voiced by ISTA over a number of years in relation to the revision of science syllabi. The new draft syllabi submitted to the Minister, provide only a list of topics and related learning outcomes. There is no indication of the depth of treatment required for the various topics. There is also a lack of clarity regarding mandatory experiments and the assessment of practical work. Even highly experienced science teachers are struggling to interpret the new syllabi.

The report analyses physics, chemistry and biology syllabi for senior cycle pupils (16 – 18 year olds) in a number of other countries/systems. The systems chosen for detailed analysis are those which are similar to the Irish system i.e. they are high stakes systems where assessment and certification is centralised (i.e. not school-based); pupils are assessed in at least six subjects; the assessment and certification are accepted for third level entry; and the syllabi have recently been revised or are in the process of revision. The systems analysed are the Scottish Highers (assessed and certified by the Scottish Qualifications Authority); the Victorian Certificate of Education (Victoria, Australia) and the Diploma of the International Baccalaureate Organisation.

The report finds that in every system analysed in the study, the syllabi include considerable detail about depth of treatment, examination specification, practicals and laboratory experiments as well as providing extended advice for teachers and pupils.

While learning outcomes are specified in all the syllabi, they are only one element of the detail provided. The report is adamant that it is not sufficient to describe a high stakes examination programme solely in terms of topics and learning outcomes and points out that learning outcomes are statements of essential learning, and as such they are written at minimum acceptable or threshold (pass / fail) standard. If teachers focus only on learning outcomes, there is a real risk that the teaching and learning targets will be at a minimum rather than a maximum level, that the bar will not be set high enough for student learning, and that as a result, standards will fall.

While recognising that the draft syllabi proposed by the NCCA might be seen as avalid first step, the report recommends that more detailed information about the depth of treatment of subjects and the requirements for examination be provided before the syllabi are approved. It also recommends that the full range of syllabus documentation (including teachers' notes, examination specifications etc.) should be officially published at the same time as the syllabus itself, under the logo of the DES (Department of Education and Skills) as has been the case in the past. This elaborated documentation should be available well before the syllabus is due to be implemented, to enable teachers to become familiar with the new material and to undergo appropriate professional development and up-skilling. The report also suggests that consideration might be given to collaborating with other bodies, nationally and internationally, to provide appropriate state-of-the art curricular resources and materials (including online and web-based resources) thereby avoiding unnecessary and expensive duplication or re-inventing the wheel.

The report points out that the three science syllabi are the first existing Leaving Certificate subjects to be revised under the new curricular framework drawn up by the NCCA. Hence it is particularly important that the proposed design and format of the proposed syllabi be scrutinised and analysed to ensure that the theoretical framework is meaningful and capable of implementation. The report also remarks that it is almost inevitable that the concerns raised by ISTA will be echoed by other subject teachers and associations as well as by third level representatives if the matter is not addressed now.

Mary Mullaghy, chairperson of the ISTA issued a statement where she welcomes modernisation of the syllabuses so long as the depth of treatment is clear. She acknowledged and supported the work of Prof. Hyland, which she said had *"identified major concerns… It is clear from the Hyland Report that the draft syllabi finalised by the NCCA do not measure up to international best practice."*

Ms. Mullaghy also went on to say that, *"It is clear from Professor Hyland's report that the benchmarking exercise carried out by the NCCA appears to be seriously flawed."*

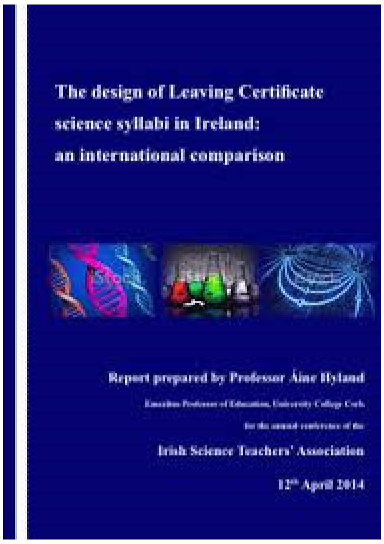
In 2011 the ISTA highlighted its concerns about the syllabus design in four submissions to the NCCA (See Appendix B p. 48 – 68 in Hyland Report) but all of these concerns appear to have been ignored by the NCCA. Hence, we were left with no option but to commission Professor Áine Hyland to undertake this important research.

In her statement, Ms. Mullaghy called for a complete overhaul. "It is not a question of just "adding on" extra information to the current syllabi in the form of uploading online material. The fundamental design used to draft the syllabi is flawed and this design needs to be changed from that of a syllabus simply containing a list of topics and learning outcomes to a design that incorporates depth of treatment, laboratory practical activities, teacher demonstration experiments and Science, Technology and Society material. All of these important aspects are contained in the Leaving Certificate Biology, Chemistry and Physics syllabi that are currently being taught in our schools."

Ms. Mullaghy also dismissed the possibility of rote learning. *"One of the reasons given by the NCCA to our ISTA representatives on the syllabus committees for deliberately keeping the syllabus vague was that 'over-specification of syllabus design contributes to rote learning'. Professor Hyland clearly shows in Chapter 4 of her report that there is no foundation whatsoever in this assertion."*

She finished her statement by issuing a direct call to the Minister for Education and Skills. *"The ISTA calls on the Minister for Education and Skills to study and implement the recommendations of the Hyland Report in full. Based on the report findings we call on the Minister to reject the current draft of the Leaving Certificate biology, chemistry and physics syllabi submitted to him by NCCA and to ensure that the syllabi are brought up to* *international standard of best practice in syllabus design as outlined in the report."*

Charlie Dolan Chair of the IBEC Education & Skills Group who is the current President of the ISTA stated: *"From the perspective of industry - the ultimate employers of scientific graduates, it is vital that the current standard of Leaving Certificate syllabi of Biology, Chemistry and Physics are of the highest standards and retain their international recognition. One of the key factors in attracting global companies in Pharma and IT sectors to Ireland has been the quality of the graduates. The Leaving Certificate syllabi are the foundation for many of these graduates and as we move into a time of renewed industrial growth, it is crucial that any changes to syllabi maintain these high standards into the future."*



The Hyland Report:

The design of Leaving Certificate science syllabi in Ireland: an international comparison

Executive Summary

The Leaving Certificate syllabi in physics, chemistry and biology are currently being revised by the National Council for Curriculum and Assessment (NCCA). During the course of the revision, concerns about the proposed design and content of the new syllabi were raised by the Irish Science Teachers Association (ISTA). In particular, ISTA is of the view that it is not sufficient to present the draft syllabi only in terms of broad topics and learning outcomes. I was asked by ISTA to undertake research on the design and specification of syllabi, and to identify international best practice in curriculum design and particularly in the design of science syllabi. This report is the outcome of the research.

In benchmarking the format, design and content of the proposed new syllabi against international comparators, this report has focused on centralised (not school-based) systems of assessment and certification. In each of the three systems chosen - Scotland, Victoria (Australia) and the International Baccalaureate Organisation (IBO) – the assessment and certification of pupil performance at senior cycle is centralised. The three systems are also similar to the Irish system in terms of the breadth of the curriculum at senior cycle, i.e. pupils take six or more subjects for award purposes.
They are also systems which are regarded as high-stakes, in that their awards are accepted by prestigious third level institutions for the selection of students. And in all three cases, the curriculum and syllabi have either been recently revised or are in the process of revision. The main focus of comparison in the report is on the format, extent and depth of treatment of the topics associated with the examination syllabi.

Comparing senior cycle science syllabi in the three systems chosen with the NCCA draft Leaving Certificate science syllabi, the report notes a significant difference between the three systems and the NCCA draft syllabi. While the NCCA documentation resembles the national curriculum and assessment guidelines of Education Scotland, and of the Australian Curriculum and Assessment Authority, it differs significantly from the detailed examination syllabi provided by the examining and awarding bodies in Scotland (the Scottish Qualifications Authority), in Victoria, Australia (the Victorian Curriculum andAssessment Authority) and the International Baccalaureate Organisation (IBO).

It would appear that for international benchmarking purposes, the NCCA has used the curriculum framework *Curriculum for*

Excellence of Education Scotland, and the national curriculum framework for the whole of Australia, set by the Australian Curriculum, Assessment and Reporting Authority (ACARA), rather than the examination syllabi provided by the Scottish Qualifications Authority (SQA) and by the state of Victoria's Curriculum and Assessment Authority (VCAA), which in the view of this researcher are the more relevant benchmarks.

The report concludes that it is not sufficient to describe a high-stakes examination programme in terms merely of topics and learning outcomes, as the NCCA has done in the draft syllabi. More detailed information about the depth of treatment of subjects and the requirements for examination must be provided at national level in Ireland to bring the syllabi into line with international good practice. Such information could be in the form of course and unit support notes (as in Scotland) or study design (as in Victoria) or a comprehensive chemistry interactive syllabus (as in the IBO). The "depth of treatment" approach with which Irish chemistry teachers have been familiar for the past decade would be another option.

In every public examination system identified for this report, the syllabi for the end of senior cycle examinations include considerable detail about depth of treatment, examination specification, practicals and laboratory experiments and other advice for teachers and pupils. While learning outcomes are specified in all the syllabi, they are only one element of the detail provided. This researcher has not come across any centralised or public examination syllabus at this level which provides only a list of topics and learning outcomes.

The report argues that while learning outcomes are a very valuable tool for identifying what learners should know and be able to do at the end of a course or programme, it is not appropriate to use learning outcomes alone to define a syllabus and its assessment. Learning outcomes are statements of essential learning, and as such they are written at minimum acceptable or threshold (pass / fail) standard. If teachers focus only on learning outcomes, there is a real risk that the teaching and learning targets will be at a minimum rather than a maximum level, that the bar will not be set high enough for student learning, and that as a result, standards will fall.

The draft syllabi for physics, chemistry and biology have now been submitted by the NCCA to the Minister for Education and Skills who (under the terms of the 1998 Education (Ireland) Act) is the ultimate decision-maker in relation to curriculum and examinations. It is a matter for the Minister to decide on the next steps. He can accept or decline the advice of the NCCA or he can refer the draft syllabi back to the NCCA for further elaboration on the basis suggested above. Alternatively, he can seek more elaboration on the syllabi elsewhere, e.g. from the inspectorate or the SEC. Whichever approach the Minister decides to take, the full range of syllabus documentation (including teachers' notes, examination specifications etc.) should be officially published at the same time as the syllabus itself, under the logo of the DES as has been the case in the past. This elaborated documentation should be available well before the syllabus is due to be implemented, to enable teachers to become familiar with the new material and to undergo appropriate professional development and up-skilling.

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Comments:

The Hyland Report received extensive coverage in the Irish papers following its launch, but whether this will influence the NCCA or the Minister of Education remains to be seen. One major change in the equation that has occurred since the report was published in April, is the replacement of Ruari Quinn by Jan O'Sullivan as Minister of Education (so that he above needs to be replaced by she). It may be that the change of leadership will allow for change and revision or a slowing down of the process of curriculum change, without a loss of face.

At the very least the new LC science courses should be revisited and adjusted in the light of the new Junior Science specification (due out in September 2014). Revising the LC science subjects before the JCSA science course was finalised was a mistake and it is vital that the LC science subjects build on the junior cycle content and teaching approach. At the moment there is a major jump from JC Science to LC sciences, and this will be worse as the JCSA science course is 200 rather than 240 hours as at present.

The Hyland Report has been criticised because it only looked at 3 school systems. However, they were chosen for their similarity to Ireland and I think that the findings would have been the same if 10 or 20 school systems had been reviewed. There are four main components of the curriculum (Figure 1):

- **Content** – what is taught
- **Pedagogy** – how it is taught
- **Outcomes** – what is expected from students
- **Assessment** – how we assess students' learning in relation to outcomes

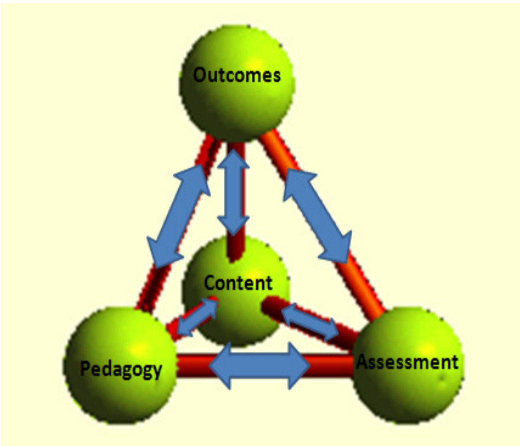

Figure 1 The curriculum components

When developing a course there should be a continuing interplay between the four components. The content is usually outlined first, depending on the level and purpose of the course. The developer then asks, 'what are appropriate learning outcomes from this content?', which may lead to a revision of the content and then the objectives. Simultaneously the developer is asking how the outcomes can be assessed, and again there is an interplay between content, outcomes and assessment. What are appropriate teaching methods or the content that match the desired outcomes and assessment procedures? This is an iterative procedure, as all four components influence the others. The fine-tuning of the curriculum, which should be informed by the results from science/chemical education research (SER/CER), ensures that all the components are in harmony and are internally consistent. But one cannot have a curriculum which is only content or outcomes or pedagogy or assessment: we need all of them for a workable and effective and educationally sound curriculum.

We intend to feature the new LC Chemistry syllabus in this and future issues of *CinA!* Below you will find a view from John Daly of the ISTA Chemistry sub-committee and then a commentary by Dr Michael Seery (DIT) from his *Education in Chemistry* blog.

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Update on LC Chemistry draft specification

John Daly

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The Leaving Certificate **Chemistry Specification** has been further revised and modified following meetings with the NCCA held in October/December 2014. The ISTA remain very unhappy regarding the depth of treatment of the learning outcomes and have made numerous efforts to engage in dialogue with the NCCA to address these concerns. After much correspondence the NCCA finally agreed a date – Friday 25th April 2014 – to meet with ISTA representatives. In the interim the ISTA commissioned a report by Professor Áine Hyland (UCC) to compare the depth of treatment of specific topics on the senior science specifications with international specifications. The report was launched at the AGM in Galway and makes interesting reading. The ISTA requested that a final decision by NCCA council on approving the specifications be postponed until after the launch of the Hyland report. However, at its meeting of March 20th 2014 the National Council for Curriculum and Assessment approved the draft specification. This is to be sent to the Minister for Education and Skills.

Structure

The draft specification is structured into **five units** of study (see Figure 1):

Unit 1: 'Scientific practices' sets the context for the four units that follow.

Unit 2. Properties, structure and bonding.

Unit 3. Chemicals in action.

Unit 4. Organic chemistry.

Unit 5. Environmental chemistry

The curriculum specification is presented in the form of learning outcomes. The outcomes are statements of what the learner should know and be able to do having completed the unit of study. There are five skills identified in the syllabus as central to teaching and learning across the curriculum at senior cycle. These skills are (i) information processing, (ii) being personally effective, (iii) communicating, (iv) critical and creative thinking and (v) working with others. The key skills are embedded in the learning outcomes of the syllabus and will be assessed in the context of learning outcomes.

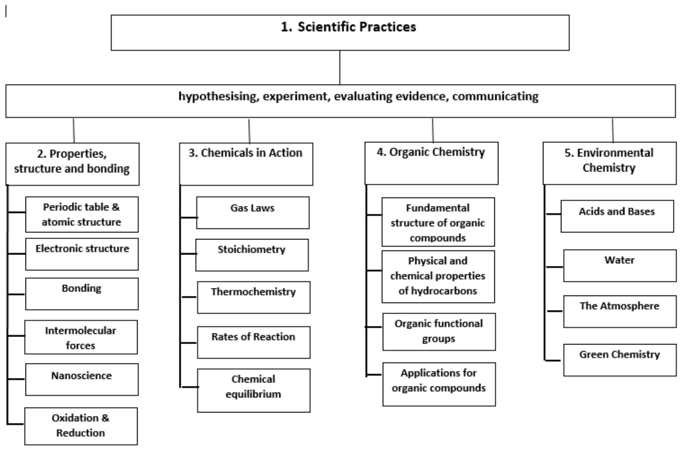

Figure 1 Structure of the new LC Chemistry syllabus

An example of the sort of learning outcomes specified in the syllabus is given below for the topic 'Nanoscience'.

Nanoscience:

- Appreciate that nanoscience is the science of the very small and that nanotechnology is the manipulation of matter at the microscopic level to produce novel materials which are the subject of current research and development.
- Outline two potential applications of nanotechnology.

Specified practical activities

Learners are required to complete and report on a number of specified practical activities. These activities are included as learning outcomes in the specification and are denoted by an asterisk. There is no particular method specified for these activities. The activities are planned and carried out in groups and reported on individually. Where appropriate, these reports should include video, audio, and electronic graphical analysis.

During the course of their study, as well as the specified practical activities, learners are required to **research a topical issue** in chemistry and plan and undertake a practical investigation related to the topical issue they have investigated. As of their investigation learners collaborate to gather and process data, evaluate evidence, and develop arguments. They read about current research and developments in science and relate their learning to the applications and implications of science for society and the environment. Learners collaborate to prepare and present a scientific communication describing the research question, methodology, results and conclusions of their open ended investigation. The reports on these practical activities are not directly assessed; however, the skills that learners develop as they carry them out and report on them are assessed in both the written and practical examination.

Technology

Technologies should be included in activities whenever it enhances student learning, for example by enabling students to complete work more efficiently or to complete work that could not otherwise be done. It should be used to collect, record, analyse and display data and information. Software simulations, virtual laboratories and games offer access to contexts for problem-solving and science investigations that are difficult to illustrate in other ways.

Assessment

Assessment for certification is based on the aims, objectives and learning outcomes of the specification. Differentiation at the point of assessment is achieved through examinations at two levels — Ordinary Level and Higher Level.

Assessment components

There are two assessment components at each level:

Total marks 400

- written examination (70%) 280 marks
- assessment of practical work (30%) 120 marks.

Both components of assessment reflect the relationship between practical work and the theoretical content of the specification. Table 1 shows an overview of the proposed assessment.

Table 1 Overview of assessment

Mode	Section	Style	Marks	% of marks
Written			**280**	**70%**
	Section A	Short answer questions; 16 with no choice	80	20%
	Section B	Structured, 3 from 4	150	37.5%
	Section C	Synoptic, 1 from 2	50	12.5%
Practical		Practical assessment	**120**	**30%**

Written examination

The written examination will be assessed at Ordinary and Higher level. It will be made up of a range and balance of question types: short answer questions, open-ended answers and extended response questions. The questions will require learners to demonstrate knowledge, understanding, applying, analysing, evaluating, and creating to an appropriate level. The key skills are embedded in the learning outcomes and will be assessed in the context of the learning outcomes.

The written examination paper will assess:

- knowledge and recall of science facts, principles and methods,
- application of chemical knowledge and understanding from different areas of the specification to familiar and unfamiliar situations,
- scientific inquiry, formulation of hypotheses and design of investigations,
- critical thinking, the ability to analyse and evaluate information and to form reasonable and logical argument based on evidence,
- problem solving based on integration, analysis and evaluation of qualitative and quantitative information and data,
- understanding the ethical, historical environmental and technological aspects of science, and how science contributes to the social and economic development of society.

The written examination paper will be 2.5 hours long and will have three sections – A, B and C.

Section A: (80 marks (16x5) will consist of 16 short questions that address core chemistry topics across the entire specification. There is no choice in this section. The short questions focus on concepts and skills rather than on the recall of facts.

Section B: (150 marks (3x50) will consist of four structured questions from which students choose three. Although drawn from one area of chemistry, the structured include a variety of scientific ideas in the context of one chemical topic.

Section C: (50 marks) will consist of two synoptic questions from which students choose one. These questions will require learners to create knowledge across a number of learning outcomes. The questions are based on a context but draw from across different areas of the chemistry specification.

Practical assessment

The laboratory-based examination is a 90 minute performance assessment and is a combination of direct and indirect assessment. This will be assessed at common level but a differentiated marking scheme may apply.

Learners carry out a series of short tasks based on the **specified practical activities**. As they carry out their task, students are observed by an external examiner who will award 60 marks (15%) **directly**.

A further 60 marks (15%) is available for the **indirect** assessment of the tasks.

At points indicated in the examination, students call the examiner over, at which time the examiner awards marks directly according to a marking scheme. The indirect assessment will be based on the collected data and/or observations, which will be marked by the SEC alongside the written paper.

Glossary of Terms

An appendix to the syllabus document contains a glossary of terms designed to clarify the learning outcomes throughout the specification. The action verb is described in terms of what the learner should be able to do. This glossary will be aligned with the command words used in the assessment.

Comments from the ISTA Convenor, John Daly

The syllabus has many good points but is **structurally flawed as it stands** as has been clearly shown in the Hyland report.

With reference to the "**Depth of Treatment**" issue, the NCCA has had great difficulty taking on board more than two years of professional guidance and suggestions offered by the ISTA and other interested parties. It was hard to know if this was due to ideological reasons.

The latest hope is that the **teacher guidelines** that will attach to the learning outcomes on the electronic form of the syllabus will be acknowledged by the NCCA and the SEC as setting clear boundaries for required **learning** and for **assessment**.

Meanwhile this autumn the ISTA, through correspondence with the Minister, is endeavouring to have the issues raised by the Hyland report addressed properly before the new syllabus is introduced.

It is an exhausting and irritating business dealing with the mind-set at the NCCA. They exhibit such an uncaring attitude to the real working life of a science teacher in the classroom, all the while sitting in their Ivory towers on Fitzwilliam Square impressing each other and nobody else.

It has also been made clear recently that the support material for the learning outcomes will be in place before the new syllabus specifications are introduced to schools.

The exact form of the second mode of assessment has to be determined and is to be trialled. The ISTA is pleased to learn that there will be an external oversight of the NCCA trialling.

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What's wrong with Leaving Cert Chemistry?

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Structure of the syllabus

As professional chemists looking back on our education, the Leaving Certificate makes perfect sense. A lot of chemistry is about understanding categorisations. We know the properties of the halogens and the typical reactions of alkenes because from early on in our chemistry education, we built up an index card set of group properties and reaction types, and a whole lot more. For a subject that is based around the periodic table, this logical and sequential approach is obvious. Start with the atom, and build up. By the time we finish our degree, we might reach some interesting applications.

There is no doubt that students who remain with chemistry for the long haul are rewarded. Many students in school today, who pursue a career in chemistry, will be exploring exciting new opportunities in smart materials, solar energy, synthesising new and intelligent medicines, and a lot more.

But this emphasis on considering the Leaving Cert as a preparatory exam for further study, as opposed to a subject in its own right in school, is a disservice to all students who are taking chemistry. The atoms-first approach means that after completing two years of study, school students have very little literacy with regards to how chemistry is relevant in the real world. I think that this is the most significant failing of our subject.

Having completed a two-year cycle in chemistry, we should expect that the syllabus has enabled our students to be able to engage with the scientific matters affecting our society: clean air and water, renewable energies, global warming, etc. Of course, we are not saying that they will be experts at this stage. But we can expect that they will at least be able to explain the fundamental concepts of these topics to other members of society. In other words our Leaving Cert should be educating the future citizens of our society, not just preparing them for the next stage in their study.

Who is the syllabus for?

It should be doing this, at the very least, because like most Leaving Cert subjects, most students taking chemistry don't end up pursuing chemistry. I consider that there are three types of student studying Leaving Cert chemistry.

The first is those with an interest in science, and who see, like in the good old days, that learning about Thompson and Kekulé are all part of the bigger picture, and are in it for the long haul—they want to have an index card set.

The second group are those who study chemistry for another discipline—they want to study medicine or pharmacy and know having chemistry will give them a head start. These students are highly motivated, but probably don't care if the main text is *The Sceptical Chymist*; they will learn what is required to do well in the exam.

Finally there are those in the third group who might try chemistry just as a subject to do, but have no intention, at least at the start of 5th year, of ever pursuing the subject further. An enthusiastic teacher is probably the most likely reason they might change their mind.

The Leaving Cert syllabus has the difficult job of addressing these different types of students. The National Council for Curriculum and Assessment recently had a review of the syllabus and asked for submissions. The report is now available on the NCCA website. Many of the discussions about the syllabus focus on whether particular components should be changed. Should there be a bit less history of chemistry? Should we focus on naming compounds or their properties? This tinkering fails to address the real problem of the syllabus: it is not interesting and is of little value to students who are studying it. In their submission to the revised syllabus proposals, the National Centre for Excellence in Mathematics and Science Teaching and Learning stated: "*one would have hoped for a more radical approach*."

There is a general consensus that the syllabus is too long. When I first looked at what students who were coming into college would know before I started teaching them, I was astounded by the breadth of the syllabus. It has all the symptoms of being designed by committee, with a little piece of everyone's pet topic included. The result is a lot of content with little depth. No-one can agree on what should be cut. One submission to the NCCA said that the Leaving Cert was too long, but then went on to suggest additions that should be included!

What can be changed?

Instead of tinkering with the syllabus, we should rethink again what the Leaving Cert is for. University educators don't rely on Leaving Cert chemistry, so we need to stop the need to feel that the sole focus is to prepare students for college. I imagine most university educators would be happy if students had a good grasp of basic stoichiometry. What is much more valuable to us, and society at large, are students who are enthused about the subject. This leaves a lot of scope for what can be done at Leaving Cert.

One of the many options available is to teach chemistry in a contextualised manner. Instead of starting with the atoms, we could start with, for example, a polluted river, and work backwards; taking in some water chemistry, acids and bases, titrations, organic compounds, etc. It can include elements of genuine problem solving, regional relevance (e.g. sampling of local water supplies), and team work. Chemistry textbooks could be showcases of the interesting and varied topics within our subject. There is no need to know everything - just what is relevant to this problem. But at the expense of breadth, this would be a much deeper awareness of the chemistry of these topics.

This approach presents the chemistry in an interesting and relevant manner, but also presents it in terms of how students will come across it in the real world. Therefore, they will be able to make meaningful contributions to society at large on these topics as they will know have the language of the context. Context based teaching is well established in other countries such as Germany (www.chik.de) and USA ("Chemistry in the Community"). I have described the implementation of context-based teaching in Israel elsewhere (http://wp.me/p3Xe17-gE).

Alignment of content and assessment

Of course much of the NCCA's work will be rendered meaningless if there is not significant reform in the assessment of the content. Well-considered learning outcomes are futile if the assessment focuses on rote-learning. There needs to be better alignment of what the NCCA set out to do and what the State Examinations commission assesses. Again there are already significant resources out there on assessing context -based learning.

Speaking recently of third level, Dr Muiris O'Connor of the Higher Education Academy said that one advantage of being a bit behind the curve meant that we could learn from the trials and mistakes of others. He's right. Let's rethink our Leaving Cert chemistry syllabus and transform it into one that showcases the wonder and beauty of our subject.

Michael Seery is a lecturer in Dublin Institute of Technology. The views expressed here are personal. Michael's blog can be accessed at: http://michaelseery.com/home/index.php/category/royal-society-of-chemistry/

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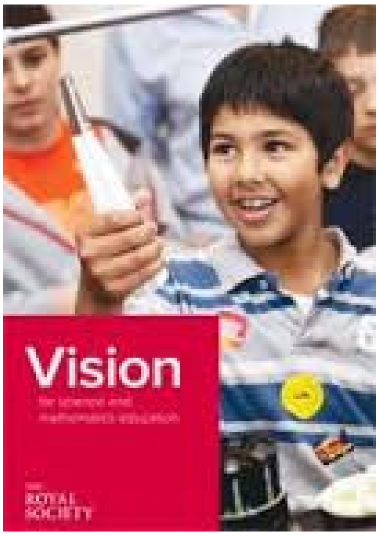

Royal Society Report on 'Vision for science and mathematics education'

The Royal Society Science Policy Centre report 01/14
Issued: June 2014 DES3090
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Available at: www.royalsociety.org/vision

Our Vision and recommendations

OUR VISION

All young people study mathematics and science up to the age of 18.
Create new baccalaureate-style frameworks that encompass vocational and academic learning across a broad range of subjects to age 18.

RECOMMENDATIONS

• Develop rigorous new post-16 courses and qualifications in mathematics, science, engineering and technology to engage students who are studying non-STEM subjects at school or who are training in the workplace, ensuring these meet the changing needs of employers.
• Increase the amount of time and money invested in practical and problem-solving work in science and mathematics education for 5–18 year olds, through access to adequately resourced laboratories and well-trained teachers.
• Extend the age at which students leave formal education or training to 18 in Northern Ireland, Scotland and Wales.

OUR VISION

Curricula and their assessment are stabilised and support excellent teaching and learning.
Use the expertise and independence of the STEM professional bodies, under strong over-arching bodies, to stabilise the curriculum and assessment, providing quality and coherence in 5–18 science and mathematics education.

RECOMMENDATIONS

• Establish new, independent, expert bodies in England and Wales, and enhance existing structures in Northern Ireland and Scotland, to provide stability in curriculum and assessment and allow teachers space to innovate in their teaching.
• Commit to invest in these bodies long-term to enable STEM experts, including employers, to contribute their knowledge and experience.

OUR VISION

Teachers have high professional status and there is a strong supply of science and mathematics specialists.
Widen access to science and mathematics teaching and enhance their appeal to prospective entrants and returners by expanding the STEM professional community's role in recognising professionalism in teaching.

RECOMMENDATIONS

• Require all school and college teachers to work towards a suitable teaching qualification to ensure they are experts in teaching as well as in their specialist subject.
• Retain STEM technicians in schools and colleges on permanent and well-paid contracts.
• Make subject-specific professional development a core requirement for teachers and technicians and link this to career progression.
• Invest over the long term in national infrastructures which provide access to subject-specific professional development for all STEM teachers and technicians.
• Ensure that every primary school has, or has access to, at least one subject specialist teacher in both science and mathematics and that all post-

primary science and mathematics lessons are taught by suitably qualified subject specialists.
• Train and reward teachers to engage fully with digital technologies to improve students' experience of, and attainment in, science and mathematics.

OUR VISION

Students understand the significance of STEM through better careers awareness and guidance. Maintain investment in large-scale, national programmes and events, delivered locally, which provide students with STEM role models and help teachers and families to develop better engagement with academia and industry.

RECOMMENDATIONS
• Build careers awareness from primary school onwards by giving children exposure to role models, such as professional scientists, engineers and technologists.
• Make careers information, advice and guidance from early secondary onwards an essential part of the school/college week.
• Increase parents' understanding of how STEM offers many and varied employment opportunities for all children, regardless of their social or economic status.

OUR VISION

The success of students, teachers and education systems is judged through appropriate and broadly based assessment and accountability measures. Ensure teachers have an increased role in assessing student achievement in public qualifications. Judge the health of the school and college systems through broader measures including ones that reflect the features of high quality STEM education.

RECOMMENDATIONS
• Entrust teachers with increased responsibility for assessing students' achievements.
• Place practical work and problem-solving at the heart of good assessment of science and mathematics.
• Use a wider set of measures than examination performance to make more informed judgements about the quality of a school or college.
• Measure the quality of science and mathematics provision in schools and colleges through specific STEM-related indicators, such as tracking the number and diversity of students taking STEM qualifications to 16 and post-16.
• Require all school and college governing bodies to have at least one member with STEM subject expertise.
• Increase the emphasis in school and college inspections on identifying and sharing good practice.

OUR VISION

Education policy and practice are better informed by evidence.
Enhance collaboration and communication between science and mathematics education researchers, scientists and mathematicians, teaching professionals, policy-makers and the public.

RECOMMENDATIONS
• Establish agreed standards for educational research to ensure good practice and to give users confidence in its results.
• Invest in education research and test and evaluate new programmes prior to rolling them out nationally.
• Encourage professional and learned STEM bodies to embrace teachers and STEM education researchers in their networks.

Comment:

This is an important report based on widespread consultation in the UK STEM community and comes from an authoritative source, although the report is only advisory and was not commissioned by the UK government. Some of the proposals match the Irish curriculum (broad-based baccalaureate-type curriculum with a mix of humanities and science and maths subjects), but go further in suggesting that science (as well as mathematics) should be compulsory for all students to age 18. At present ~95% of Irish LC students already take mathematics at some level but a sizeable percentage do not take any LC science subject, although a majority take one or more science subject. The importance of science technicians and regular CPD for teachers and the need for proper piloting and evaluation of new courses will strike a chord with Irish teachers, even if they are only aspirations at present. It will be interesting to compare the RS Report with the report of the Irish STEM Review Group, which is due out at the end of the summer. We hope to comment on this in the next issue.

In addition the report (which can be accessed on line at www.royalsociety.org/vision) also specifies what is meant by a scientifically informed individual (p.29):

A scientifically informed individual:
(i) understands scientific theories and concepts and that these are subject to challenge and change as new evidence arises;
(ii) can think and act scientifically (e.g. using hypotheses to test and solve problems while also using scientific knowledge) and uses essential reading, writing, mathematical and communication skills to analyse scientific information accurately;
(iii) makes informed interpretations and judgements (e.g. risk assessment) about scientific information and the world at large as well as engaging constructively in debate on scientific issues;
(iv) is able to apply scientific knowledge and understanding in everyday life; and
(v) maintains curiosity about the natural and made worlds. (p.29)

The Report also has something to say about reforming the curriculum in science and mathematics (p. 67), and these guidelines have great relevance to Ireland and the debate about the new LC science courses (see above).

... the introduction of new curricular innovations should be based on:
• *analysis of comprehensive performance statistics;*
• *the findings of a coordinated programme of planned short-term studies and longitudinal research evidence;*
• *full and proper consultation with the education community and the wider public; and*
• *robust piloting of new interventions and careful consideration of independently conducted evaluations*. (p.67)

There is a lot more in the report that is worth reading (e.g. on assessment and the role of practical work) and we recommend it to your consideration
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Teaching Council requirements to teach Chemistry

http://www.teachingcouncil.ie/_fileupload/Registration/Subject%20Criteria%20documents/Curricular%20Subject%20Requirments%20after%20January%202017.pdf

*In order to meet the registration requirements set down in the Teaching Council [Registration] Regulations in respect of the curricular subject of Chemistry, an applicant must meet **all** of the following criteria:*
1. (a) Applicants must hold a degree-level qualification, with Chemistry studied up to and including third-year level or higher (or modular equivalent).
(b) The qualifying degree must be equivalent to at least Level 8 on the National Framework of Qualifications (NFQ) and with a minimum pass[1] result in all examinations pertinent to the subject of Chemistry.
(c) The qualifying degree must carry at least 180 ECTS (European Credit Transfer System) credits (or equivalent) with the specific study of Chemistry modules comprising at least 60 ECTS credits (or equivalent) and with not less than 10 ECTS credits (or equivalent) studied at third-year level or higher (or modular equivalent).
2. The study of Chemistry during the degree must show that the holder has acquired sufficient knowledge, skills and understanding to teach the Chemistry syllabus[2] to the highest level in post-primary education (see www.curriculumonline.ie). To meet this requirement the degree must include the study of all of the following essential areas to a minimum of 40 ECTS credits (or equivalent):

Essential areas of study
(a) Organic Chemistry[3]
(b) Inorganic Chemistry[4]
(c) Physical Chemistry[5]
(d) Analytical Chemistry[6].

The remaining 20 ECTS credits (or equivalent) may be in any of the essential areas above or may be drawn from the following optional areas:

Optional areas of study
(e) Environmental Chemistry[7]
(f) Materials Chemistry[8]
(g) Pharmaceutical Chemistry/Biopharmaceutical Chemistry[9]
(h) Industrial Chemistry[10].

3. Laboratory practical work in chemistry must have been completed throughout the degree programme.

4. Applicants must also have completed a programme of post-primary initial teacher education (age range 12-18 years) carrying a minimum of 120 ECTS credits (or equivalent)1. The programme should include a methodology module(s) on the teaching of a Science-based subject with a minimum of 5 ECTS credits (or equivalent)[2].

Science (Junior Certificate)
An applicant who meets the registration criteria for **Chemistry** will also meet the requirements for the Junior Cycle curricular subject **Science** if he/she has studied a minimum of 10 ECTS credits (or equivalent) in Biology and a minimum of 10 ECTS credits (or equivalent) in Physics.

Footnotes:
1 Which includes pass by compensation.
2 As approved by the Minister for Education & Skills, and published by the National Council for Curriculum and Assessment (NCCA).
3 This may include modules in the areas of Structure and Reactivity of Organic Compounds, Functional Group Interconversions, Stereochemistry, Organic Reaction Mechanisms, Aromatic Chemistry, Organic Polymers, or Organic Synthesis.
4 This may include modules in the areas of Main Group Chemistry, Transition Metal Chemistry, Organometallic Chemistry, or Structure and Bonding.
5 This may include modules in the areas of Energetics and Kinetics, Thermodynamics, Chemical Equilibria, Quantum Mechanics or Electrochemistry.
6 This section may be studied as "stand alone" modules in Analytical Chemistry or may be integrated into modules of Inorganic Chemistry, Organic Chemistry or Physical Chemistry. The study of Analytical Chemistry may include Instrumentation in Chemical Analysis and Spectrometry (atomic absorption, ultraviolet, infrared, NMR, mass spectrometry) GC, HPLC, Electrochemical Methods, or Solvent Extraction.
7 This may include modules in the areas of Water Chemistry, Atmospheric Chemistry, or Pollutants in the Environment.
8 This may include modules in the areas of Solid State Chemistry, Crystallography, or Band Structure.
9 This may include modules in the areas of Drug Design, Structure-Activity Relationships, or Synthetic Methods.
10 This may include modules in the areas of Batch Process, Continuous Process, Industrial Safety, or Industrial Case Studies.

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How long to produce a science/chemistry teacher?

At the moment there are several routes to producing second-level science teachers in the Republic. The concurrent model is a 4 year honours degree, including education, science, pedagogics and teaching practice. The science subjects to be taught in school (usually 2) are taught alongside education, so that science teachers are produced in 4 years. The other main route is the consecutive model, where science graduates take the Professional Diploma in Education (PDE), which includes education, pedagogy and teaching practice. This course took one year but from Sept. 2014 it has been extended to a 2 year course. This route takes 5 (now to be 6) years to produce a science teacher. There is also a distance learning course offered by Hibernia College for graduates.

Two of the providers of concurrent courses (UCD and NUIM) have moved or are moving to a 5 year model, with an additional year beyond the honours degree, which will give the students a Masters degree. This route to science teaching will now take 5 years. There is a move across Europe to make a Master's degree mandatory for entry into teaching. The fees for the 5th year will not be covered by the government, and those for the PDE are also not covered.

The qualifications for teachers are now set by the Teaching Council and the requirements for a chemistry teacher are given above, and are based on the ECTS system. An honours degree is 240 ECTS and 60 hours must be spent on a subject to be eligible to teach it.

There is a problem in fitting enough material into a 4 year concurrent degree to meet the Teaching Council requirements and ensure prospective teachers have enough subject matter knowledge (SMK) and enough pedagogical content knowledge (PCK) to teach a subject effectively. The new 5 year courses will allow enough time to cover enough science in the first 4 years and enough education and PCK in the 5th year, together with a research component. It will also bring the concurrent and consecutive courses more into line.

At the moment there is a free market in teacher education: there are too many courses and too many teachers being produced. There is no regulation of the number of teachers being produced or their subjects. For several years now Ireland has been over-producing science teachers (as well as teachers of other subjects) and the majority of new teachers cannot find jobs and may work, if they are lucky, for several years on short-term contracts. The growth in the birth rate now moving through primary schools will mean that more teachers and more schools will be needed in the future. But each year Ireland is producing a surplus of teachers, few of whom find full-time or part-time, temporary employment and many leave the country to find work. A science or maths teaching qualification is very valuable worldwide as many countries (but not Ireland) have a shortage of science and maths teachers, and there is a strong demand outside Ireland for English-speaking teachers – in the UK, Australia and New Zealand, many African countries and in international schools.

One of the interesting questions regarding the different models of producing second-level teachers is: which is the best model? As far as I know there is no research evidence on this question and each model has its own strengths and weaknesses. However, some recent research by Muireann Sheehan (PhD student at the University of Limerick) on the understanding of basic chemical ideas and the number of misconceptions held by trainee teachers, has shown that there is **NO** difference between concurrent students (whatever their year of study) and consecutive students(who have done a science degree first). It appears to doing more chemistry courses does not improve the understanding of basic concepts or reduce the number of misconceptions.

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Consultation on the Junior Science specification

The draft science specification was opened for comments at: http://www.juniorcycle.ie/NCCA_JuniorCycle/media/NCCA/Documents/Planning/Proofed_JC-ScienceSpec_Council_20141002.pdf for a few weeks. This consultation on the curriculum specification for Junior Cycle Science is now closed, and unfortunately due to the union decision, science teachers and the ISTA members were not able to contribute to the consultation.

The specification also includes appendices containing *Examples of student work*, a *Glossary*, and *Work to date on potential assessment arrangements*. Consultation on the assessment for certification arrangements is deferred until discussions take place between the Minister for Education and Skills and the teacher unions in October.

A one-day consultation of various interested people was held on October 14th in Dublin Castle, although without official representation by science teachers or the ISTA. The results of this consultation have been published by the NCCA. One change agreed is to rename the 'Materials' strand as 'The chemical world', to match the other strands and make chemistry more visible.

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New ISTA Chemistry Sub-Committee

A new chemistry sub-committee has been appointed by the ISTA Council and met for the first time on Saturday 12th April 2014. The members of the new committee are:

- John Daly (Convenor), Blackrock College (retired)
- Lisa Darley, Loreto Secondary School, Navan

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Pre-service Teachers' Ideas in Chemistry

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Background to the study

It is currently a concern in Ireland that students who have taken chemistry at school do not have an adequate background knowledge and understanding in chemistry on entering third level education (Childs and Sheehan 2009; Hayes and Childs 2010). Recent studies in Ireland found that chemical misconceptions are common among Junior Cycle (14-15 years old) and Leaving Cycle (16-18 years old) pupils (McCormack 2009; Sheehan 2010). Sheehan (2010) found that the majority of Junior Cycle (67.2%) and Leaving Cycle (63.8%) pupils achieved less than 40% in a chemistry concepts test.

Pre-Service Primary Teachers' Knowledge in Science

The current research aimed at investigating pre-service primary teachers' understanding of some of the fundamental concepts in chemistry. This study concentrated on pre-service primary school teachers, whereas past studies in Ireland have focused on difficulties of second level students', pre-service second level science teachers and undergraduate science students (Childs and Sheehan 2009; Hayes and Childs 2010;Regan, Childs and Hayes 2011; Sheehan, Childs and Hayes, 2011). Sheehan, Childs and Hayes (2011) found in their study that the participating pre-service science teachers held very high levels of chemistry misconceptions across all years of study of a four year degree programme. Their misconceptions were not reduced or altered in any significant way over the course of four years of study, suggesting that the education system (at all levels) in Ireland does not confront learners misconceptions in chemistry and may actually lead to the development of such chemistry misconceptions.

The aim of the study was to investigate pre-service primary teachers' understanding of some of the fundamental chemistry concepts. This involved the design of diagnostic tests with the aim of assessing pre-service primary teachers' ideas and knowledge about chemistry in a Science Education Module at an Initial Teacher Education College in the Republic of Ireland.

Research Design

This study focused on pre-service primary teachers understanding of the:
1. Particulate nature of matter
2. States of matter and changes in the states of matter such as, thermal expansion and dissolution of substances.

Phase 1: Investigating the pre-service primary teachers background in science
Questionnaires were administered to the pre-service teachers. The questionnaire gathered background information on their previous studies in science.

Phase 2: Design and implementation of diagnostic tests.
Diagnostic tests (multiple choice) were developed based on published research on both childrens' and pre-service teachers ideas in chemistry, with the aim of testing prior knowledge, understanding and misconceptions. The diagnostic tests were administered to the pre-service teachers, which tested the pre-service teachers' knowledge and conceptual understanding in four areas: *States of Matter, Particle Nature of Matter, The Effects of Heat on Matter and, Mass*. This article reports on the pre-service teachers' ideas and knowledge of States of Matter and Mass.

Results

25% were male and 75% were female (N=60). 96% of the pre-service teachers studied science for the Junior Cycle.
A quarter of the participants did not study any science subject (Agricultural, Biology, Chemistry, Physics, Phys/Chem) for their Senior Cycle. 58% studied biology, 2% studied Agricultural Science, 13% chemistry with 0% studying physical chemistry. 13% studied physics.

Pre-service teachers' knowledge and understanding of the States of Matter

When asked if they knew what matter was, 60% of the pre-service teachers (n=36) stated they did

know and attempted to explain matter in their own words. The remaining 24 pre-service teachers could not attempt to explain matter in their own words and either left the answer blank or added a comment for example: 'no' or 'not really'. However only 40% of them (n=24) could describe correctly what matter was in their own words.
Some of their answers included:
'It is what everything is made up of'
'Something you can measure or weigh'
'Smallest components of solid, liquid and gas'
'Anything that takes up space'
'Amount of volume contained within'

Many of their answers correctly stated that matter is what everything is made up of. Four pre-service teachers mentioned 'Mass' in their answers, another 15 mentioned that matter occupies space. Only three students mentioned both space and mass: *'Matter is anything that occupies space and has a mass.'*

The pre-service teachers were asked to judge whether they thought a series of items were matter or not. They were asked to classify the following as either *Matter* or *Non-Matter (Table 1).* The teachers correctly classified items that were clearly solids, liquids and gases as matter. The pre-service teachers were very clear that solids can be classified as matter. However they had problems with classifying air and classifying phenomena associated with matter (Fire, Wind, Heat, Electricity, Light). 20% thought soil was not classified as matter. Only 83% felt that milk was matter. Biological items for example, blood was only regarded by 83% as matter and meat by 80%.

The pre-service teachers were then asked further questions regarding the states of matter (Table 2). The results revealed several non-scientific views of matter, showing the pre-service teachers hold many misconceptions and do not fully understand states of matter in everyday life. 40% of participants incorrectly stated that all solids are hard, strong and non-malleable, with 13% stating they did not know. Therefore 53% of students did not fully understand that different solids have different degree of hardness, strength and malleability. The results highlight that some of the pre-service teachers are confused with regards whether jelly, sand, and plasticine are solids or not. 38% of pre-service teachers incorrectly thought Jelly was not a solid, with 10% feeling that plasticine is not a solid.

Pre-service teachers' knowledge and understanding of Mass

The teachers were given statements to rank them as true or false. These statements were used to investigate the pre-service teachers' knowledge and understanding of Mass and Matter (Table 3). The results show that pre-service primary teachers have misconceptions about the mass of solids, liquids and gases (Table 3). 69% either incorrectly thought (57%) water vapour molecules weigh the same as ice molecules or did not know the answer (12%). Further confusion about the mass was shown where 60% correctly answered that if you melt ice it becomes lighter with 13% answering incorrectly and 27% stating they did not know. 38% felt that when I blow up a balloon, the balloon becomes much lighter with 23% not knowing the answer. 12% stating that air does not have mass, and 33% were not sure. 27% felt that when sugar is dissolved in a hot cup of tea, it does not contribute to the mass of the solution as it disappears, with 38% not knowing the answer.

Table 1. Answers from the pre-service primary teachers' classification of 'matter or non-matter activity' (Numbers represent a % of the total participants, N=60).

	Correct	Incorrect	Did not answer			Correct	Incorrect	Did not answer
Iron	88	3	8		**Cotton wool**	83	0	17
Fire	62	23	15		**Air**	48	28	23
Soil	80	5	15		**Flour**	80	2	18
Wind	60	17	23		**Electricity**	55	17	28
Water	87	2	12		**Light**	57	18	25
Heat	68	22	10		**Milk**	83	0	17
Sugar	83	2	15		**Blood**	83	2	15
Meat	80	2	18					

Table 2. The pre-service primary teachers' ideas regarding the different states of matter (Numbers represent a % of the total participants, N=60).

	True	False	Did not know
1. Solids are hard, strong and non-malleable	40	47	13
2. Jelly is a solid	55	38	7
3. Plasticine is not a solid as it has no definite shape.	10	67	23
4. Sand is not a solid as you can pour it and it takes the shape of the container it is poured into	17	52	32

Table 3. Pre-service primary teachers' ideas about mass and matter (Numbers represent a % of the total participants, N=60).

	True	False	Did not know
1. Water vapour molecules weigh the same as ice molecules	32	57	12
2. When I blow up a balloon, the balloon becomes much lighter	38	38	23
3. If you melt ice it becomes lighter	13	60	27
4. When I dissolve sugar in a hot cup of tea, it does not contribute to the mass of the solution as it disappears.	27	35	38
5. Air has mass	55	12	33

Discussion and implications for teaching and learning

Results of this study highlight that the participating pre-service primary teachers held many alternative and common misconceptions on topics in Chemistry. The number of and prevalence of misconceptions among the pre-service primary teachers suggest that their understanding of the states of matter and changes in the states of matter are inadequate.

It can be argued that the main reason why the pre-service teachers held such misunderstandings may be due to the fact that most of the pre-service teachers did not come from a very strong scientific background (Murphy and Smith 2012; Waldron et al. 2009). A quarter of those surveyed did not take any science subjects at Senior Cycle. 4% of the students had not studied science during their post-primary education. However the fact of the matter is that 96% of the pre-service teachers studied science for the Junior Cycle. The concepts which they were asked about in the diagnostics tests were basic concepts covered in the Junior Cycle (states of matter). It is very worrying after studying science at Junior Cycle that the students did not hold a strong understanding in the basic foundations of chemistry.

The results raise concerns about what is being taught at second level education in Ireland (Childs and Sheehan 2009; Hayes and Childs 2010; McCormack 2009; Sheehan 2010). This study suggests that the education system in Ireland, as has been found in other Irish studies and countries, does not encourage the reduction or alteration of chemistry misconceptions in learners (Childs and Sheehan 2009; Hayes and Childs 2010). However this is not the fault of teachers, this is an issue for curricula design teams. Science and Chemistry curricula should include time to address common misconceptions, so that their students do not go through the education system with such misconceptions which are never questioned.

The aim of this article was to inform Irish Chemistry and Science teachers about and to highlight some common misconceptions that your students may hold. You may also like to use the questions from this study in your lessons to get the students' ideas on the States of Matter. It would be a nice way to get a discussion going in the class about matter and could also be used as a means of formative assessment.

References

Childs, P.E. and Sheehan, M. (2009). What's difficult about chemistry? An Irish perspective. *Chemistry Education Research and Practice*, 10, 3, 204-218.

Hayes, S. & Childs, P.E. (2010). Retaining weaker students: A pilot project in chemistry at the University of Limerick, in G. Cakmacki and M.F. Tasar, eds., *Contemporary Science Education Research: Learning and Assessment*, Ankara Turkey: Pegem Akademi, 353-360.

McCormack, L. (2009) *'Cognitive acceleration across the primary-second level transition'*, Unpublished thesis (Ph.D.), Dublin City University available:http://doras.dcu.ie/14886/

Murphy, C., & Smith, G. (2012). The impact of a curriculum course on pre-service primary teachers' science content knowledge and attitudes towards teaching science. *Irish Educational Studies,* 31, 1, 77-95.

OECD (2006). *'Evolution of student interest in science and technology studies'*. Policy Report, May 2006.

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Ireland's first Professor of STEM Education:
an interview with Professor Sibel Erduran, University of Limerick

In April 2014 Professor Sibel Erduran moved from the University of Bristol, U.K. to Ireland, to take up Ireland's first Chair in STEM Education at the University of Limerick. The professorship is located in the Department of Education and Professional Studies and Professor Erduran was also appointed as the Director of the National Centre for Excellence in Mathematics and Science Teaching and Learning (NCE-MSTL), which was set up in 2009 (www.nce-mstl.ie). I thought it would be of interest to science teachers in Ireland to know something about Professor Erduran's background, interests and plans and so I invited her to answer some questions on her career-to-date. She got off to a flying start in Ireland by speaking at the April seminar in the RIA organised by the STEM Review Group. Sibel is very well known internationally in science education circles, and frequently speaks at science education conferences, and I have met many people this year on my travels who know her and who were pleased to hear she had moved to Ireland. We also went together to the ECRICE conference in Finland in July this year, as part of a group from the University of Limerick.

1. Can you summarise your career before you came to Ireland.

Before coming to Ireland, I worked in England for about 15 years: first at King's College, University of London and later at University of Bristol. Prior to these positions, I completed my higher education in the USA. My PhD thesis on science education completed at Vanderbilt University, MSc in Food Chemistry at Cornell University and BA in Biochemistry and Chemistry at Northwestern University. I was also a research assistant at University of Pittsburgh for two years and taught chemistry and general science at a high school in northern Cyprus. Apart from these experiences, I also held Visiting Professorships at Kristianstad University in Sweden and Bogazici University in Turkey. All these experiences were clearly quite influential on my development as an educator. I do, however, cherish having grown up in a family with a tradition of teaching. My father was a great teacher and so was my grandfather. Education was very important in my family environment, and I grew up being surrounded by a lot of teachers. I have great respect for the teaching profession, and I love teaching myself.

2. The big question: why did you come to Ireland?

I was drawn to the National Centre at Limerick. In my previous positions, I had done research and CPD projects in science education, and I was looking to have a leadership role where I can encourage, facilitate and enable novel and effective teaching strategies in everyday classrooms on a larger scale to teach out more teachers and learners. I have worked with a great deal of teachers across the world, and I have come to appreciate that teachers work under very demanding conditions. From our research efforts, we have useful information that can be useful for teachers and learners but the gaps between practice, research and curriculum policy persist. So I am also quite keen to make bridges between different stakeholders so we can speak a similar if not the same language so that we can have some real impact on learners.

3. What do you see as the main challenges for Irish science education?

Like many education systems around the world, the Irish science education would also benefit from the infusion of more evidence from research into teaching and learning as well as into CPD design and implementation. The gaps that I mentioned above remain an issue in Ireland as well. In my work, I have focused on researching the teaching and learning of scientific argumentation. However, I didn't stop with the research. I have a keen interest in transforming theoretical and academic work into practical resources. I find this a very creative aspect of my work. I edited a book on the topic of argumentation (Erduran & Jimenez-Aleixandre, 2008, Springer). Argumentation is about the justification of knowledge claims with evidence. Suppose we say, "matter is made of tiny, indivisible particles". Why do we believe this claim? What's the evidence that supports this claim? Often in school science, we do not engage learners in the modes of thinking and reasoning that are so central and significant to scientists. We expect teachers and learners to accept claims as we tell them. This is not scientific at all. In fact much of school science seems very unscientific in its delivery, which is quite ironic. So apart from researching how we can infuse argumentation into CPD and science lessons, we actually designed, in collaboration with teachers, resources that are trialled and tested so that they are useful in practice. Some of these resources are cited below.

There are of course many other challenges, for instance in terms of assessment systems, curriculum content, CPD models and provision. I am happy to talk about them in more detail in due course. Regardless of the issue, though, I think changing any aspect of education requires cultural and systemic change. If I take the earlier example, you can't teach argumentation in a classroom that doesn't value evidence and justification. This is about culture change, it's about altering the expectations and attitudes about what counts as useful knowledge in a science lesson.

4. What are your current research activities?

A major aspect of my work has been about the "Nature of Science, NoS". I have a new book on this topic, which is promoting a holistic account of scientific practices in science education (Erduran & Dagher, 2014; *Reconceptualising the Nature of Science*, Springer). I am an Editor for the *International Journal of Science Education* and section-Editor for *Science Education* Journal. I serve on the Council of the International History, Philosophy and Science Teaching Group. I have recently been elected to serve on the Social Sciences Committee of the Royal Irish Academy. I have several lines of work on nature of science and argumentation that are ongoing with various colleagues. I like to supervise doctoral students, who teach me quite a lot through their own work. At the moment, I have 10 doctoral students (7 Irish and 3 from Turkey, China and Brazil), who are engaged in various projects, for instance, on engineering education and curriculum analysis. My international collaborations are from across the world. I have published with colleagues from Spain, USA, Argentina, Hong Kong, Mexico, France, UK and Turkey among others. At the moment, I am engaged in international projects with colleagues from Rwanda, Turkey and USA. Even though work in low-income countries is not a primary focus of my research, I do value doing some educational development work, particularly teacher training, in Africa. In this sense, I have carried out projects in Tanzania, Kenya, South Africa, Zanzibar and Rwanda.

5. What do you see as the future role and vision for NCE-MSTL?

One of the new directions for the Centre is the focus on STEM – Science, Technology, Engineering and Mathematics Education. So far, we have had an emphasis on science and mathematics, and I would like us to build up a more interdisciplinary focus, so that we can be aligned with some of the global trends in STEM education. The theme of interdisciplinarity is really important at the moment because a lot of issues are inherently interdisciplinary anyhow. And by this, I don't just mean interdisciplinary across STEM subjects but also across social sciences and humanities. You cannot think about investigating and resolving problems in climate science, for example, without contributions from chemists, geologists, industry partners and politicians, to name a few of the stakeholders. Many issues of our times are complex and demand collaboration and coordination across disciplines.

In a similar vein, of course we need to ensure that Irish students are equipped with the skills to deal with a changing world, where problems are getting more and more complex. Skills such as the ability to evaluate evidence, to think critically, to be able to monitor your own learning and to be literate in distilling information from media, are essential in and beyond schooling.

We need to also ensure that there is more coordination between formal and informal STEM learning contexts, for instance, between what is learned in museums, in the family, through the media and at school so that students are getting the best possible education. Of course these issues are not straightforward and would require reform in curriculum, assessment and teaching. A major part that the centre can play is to investigate what effective methods we can develop to help address such issues. I am really looking forward to getting to know the Irish science education community and to explore together such issues.

6. Can you give some examples of your publications and other work?

Erduran, S., & Dagher, Z. (2014). *Reconceptualizing the nature of science for science education: Scientific knowledge, practices and other family categories.* Dordrecht: Springer.

Erduran, S., & Msimanga, A. (2014). Science curriculum reform in South Africa: Lessons for professional development from research on argumentation in science education, *Education as Change*, 18(S1), pp.S33-S46.

Erduran, S. (2014). Beyond nature of science: The case for reconceptualising 'science' for science education, *Science Education International*, 25(1), 93-111.

Murphy, D., & Erduran, S. (2013). Enseñando quimica por medio de la argumentación: estudio de un caso usando el esquema de argumentación de Toulmin. *Educación en la Química en Línea* ISSN 2344-9683, Vol. 19 No1, pp 8-32. (Teaching Chemistry through Argumentation: A Case Study using Toulmin's Argument Pattern)

Erduran, S. (2013). Philosophy, chemistry and education: an introduction. *Science & Education*, 22(7), 1559-1562.

Erduran, S. (2013). Cocktail of Food Science and Argumentation: Shaken or Stirred for Learning? *LUMAT1*(2), 9–16. ISSN 2323-7112

Kaya, E., & Erduran, S. (2013). Integrating epistemological perspectives on chemistry in chemical education: the cases of concept duality, chemical language, and structural explanations. *Science & Education*, 22(7), 1741-1755.

Erduran, S., & Pabuccu, A. (2012). *Bonding chemistry and argument: supporting the teaching and learning of argumentation through chemistry stories.* Teacher and Student Resource. Bristol: University of Bristol. http://www.bristol.ac.uk/education/news/2012/63.html (Translated to Norwegian, http://www.naturfag.no/bokbeskrivelse/vis.html?tid=1919022 and

Erduran, S., Yee, W. C., & Ingram, N. (2011). *Assesssment and Practical Inquiry in Scientific Argumentation.* Website of CPD and Teaching/Learning Resources. www.apisa.co.uk

Erduran, S., Yan, X., & Park, J. Y. (Eds). (2011). *Fostering evidence-based subject teaching.* DVD. Bristol: University of Bristol.

Erduran, S, Tiberghien, A., & Jimenez-Aleixandre, M. P. (2011). *Science Teaching Advanced Methods: Argumentation in Science Education.* Bristol: University of Bristol.

Erduran, S. (2010). Talking chemistry in Zanzibar:

probing pupils' chemistry knowledge using videos of local pedagogies, *EduQ*, **6**, pp. 30-36. ISSN: 2013-1755. DOI: 10.2436/20.2003.02.45.

Balacheff, N., Koskinen, T., & Erduran, S. (Eds.) (2010). Technology Enhanced Science Education. *eLearning Papers*, No.20. ISSN 1887-1542

Erduran, S., & Yan, X. (Eds). (2009). *Minding gaps in argument: supporting the teaching of scientific inquiry.* Booklet and DVD. Bristol: University of Bristol.

Erduran, S., Polat, F., & Raveaud, M. (Ed.s) (2008). *step-IN Project DVD*. Bristol: University of Bristol.

Erduran, S., & Jimenez-Aleixandre, M. P. (Eds.) (2008). *Research in Argumentation in Science Education: Perspectives from Classroom-Based Research*. Dordrecht: Springer. 285p. ISBN: 978-1-4020-6669-6)

Erduran, S. (2006). Continuing Professional Development through Portfolios of Evidence: Accomplished Science Teaching in Argumentation. London: Gatsby Foundation http://www.cpdthroughpoe.com/index.html.

Erduran, S. (2004). Case Study in Ideas and Evidence. London: Key Stage Three Strategy. (http://www.standards.dfes.gov.uk/keystage3/casestudies/cs_sc_ideas)

Osborne, J., Erduran, S. & Simon, S. (2004). Ideas, Evidence and Argument in Science. Video, In-service Training Manual and Resource Pack. London: King's College London.
(Translated to Chinese, French, German and Turkish)

7. How can people contact you?

I can be contacted at the University of Limerick by email at sibel.erduran@ul.ie or at the Department of Education and Professional Studies, University of Limerick, Limerick.

Thank you, Sibel, for this interview and for filling us in on your background, current work and hopes for science education in Ireland. I hope you will have the opportunity to meet many Irish science teachers in the future and I am sure you will have much to contribute to science education in Ireland.

Peter E. Childs

Elementary Chemistry

Rare gases banned

In August 2014 the World Anti-Doping Agency (WADA) banned the use of the rare gases, xenon and argon, as performance enhancers. Evidently athletes have been breathing these gases (50:50 mixture with oxygen) in order to boost the production of red blood cells to enhance stamina. They have the same effect as training at high altitude. Although the gases have been banned, WADA currently has no way of testing for their presence or evidence of their use. The Russians have been using 'inhalation remediation' for years.

"WADA took the action after Russian skiers and biathletes admitted to using xenon at the Sochi Winter Olympics in February. The team's coach told German reporters that they used the gas because it wasn't illegal and mimicked the effects of training at altitude."
http://news.discovery.com/adventure/xenon-argon-banned-for-athletes-is-krypton-next-140902.htm

"Inhaling xenon, mixed with oxygen, is believed to improve stamina because it increases the body's production of a protein known as hypoxia inducible factor 1, or HIF1.
In turn this stimulates the production of natural erythropoietin (EPO) which regulates the number of red blood cells. The more of these cells, the more oxygen you can carry, and the greater your athletic stamina.
Doping with artificial EPO has been one of the biggest threats to the integrity of sport over the past 20 years. The clampdown on using the drug has seen sports scientists develop other methods including the use of xenon and argon."
(http://www.bbc.com/news/science-environment-28970855)

Xenon can also be used as an anaesthetic. Its anaesthetic properties were first observed in 1939 and it was first used as an anaesthetic in 1951.
http://www.aana.com/newsandjournal/documents/xenon_1010_p387-392.pdf

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Why do we teach science: four arguments for teaching science and the role of Science Outreach

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Introduction

Science in the present day is seen by politicians in the EU and in Ireland as a way of achieving economic growth (European Commission, 2007; Ireland: Department for Jobs, 2011). So, there is considerable investment in research and in attracting science-related companies. In Ireland, there are a large number of these: Google, Abbott, Boston Scientific, Paypal, just to cite a few. For them and for research institutions, science graduates are a requisite. The recent words from the former Minister for Education and Skills, Ruairí Quinn, regarding Dublin City of Science 2012 (Dublin City of Science, 2012), doesn't leave any space for doubt:

> *"inspire and motivate our young people to take up important subjects such as science and maths (…) in advancing the Government's commitment long-term in research and development and placing Ireland firmly on the map for science"*

Nevertheless the numbers taking up science are not looking good, as the recent EU report has told us (European Comission, 2011). Ireland was the worst performer when it comes to increasing its total of mathematics, science and technology graduates, up only 1% between 2000 and 2008. In the same period, the number of female science graduates in Ireland actually declined. This is not new; several countries in several different periods of time have called for a greater uptake of science by students, showing concern for the low numbers, going as far back as to the 1950's. What is interesting is that these situations tend to repeat themselves and things seem to roughly follow the same pattern (Stocklmayer *et al*., 2010). The remedy has been long prescribed in the science education literature: change the way Science is taught at the primary and post-primary level. A central issue of these calls for reform was and still is:

> **How can school both prepare some students to go on to careers in Science and technology and prepare all students to be responsible, scientifically, literate citizens?** (Stocklmayer *et al*., 2010).

This question brings to the fore the goals of science education. Why do we want to teach science, and what type of science do we want to teach to primary and post-primary level students? Four different arguments can be found in the literature for science education: the democratic, utilitarian, economic and cultural arguments (Osborne & Dillon, 2010). The four are here briefly described and two of them are highlighted.

Four arguments for science teaching

> *"Science teachers are tasked, throughout the world, with a set of almost Herculean challenges: make Science lessons interesting; inspire a set of pupils with wonder and excitement; increase the flow of entrepreneurs and technicians of tomorrow; and ensure citizens and consumers understand the risks and benefits of modern Science."* (Osborne & Dillon, 2010, page 7)

The challenges mentioned above reflect different arguments for science education itself. Four justifications are found in the literature. Two of them are:

- The Utilitarian argument – science knowledge is useful in day to day life so science education is important to help students develop skills and knowledge that are going to be valuable throughout their life;
- The Cultural argument – science is one of the great achievements of humankind so it

is important for students to understand and praise the relevance of science in our society.

Although the cultural and utilitarian arguments are relevant, policy and educational documents reflect more the other conceptions of what science education should be: the previously mentioned economic and democratic arguments. In the economic view, science education starts to fill the pipeline of future scientists and engineers, who will ensure the country's economic competitiveness. Therefore, teachers should focus on preparing and motivating students to enter this pipeline. According to the democratic argument, as only a small minority of students that study science will follow a science-related career, it is hard to justify the implementation of a scientifically-oriented curriculum. That is to say, the education of future science professionals should not be the dominant or sole determinant of science education. On the contrary, teachers' concerns should be directed to help students to become informed citizens in an increasingly technocratic and scientific world.

The four arguments for teaching science described above will influence policy and practice. The economic argument has gained relevance in the last decades in policy documents with the rise of the technological society (European Commission, 2011; European Commission, 2007). At a practitioner level, teachers are influenced differently by the four arguments. One can have a primary level teacher who teaches science one hour per week and for whom science was not a core part of her/his third level education. Or one can have a chemistry teacher who prepares students for the leaving certificate examination and who majored in science in her/his third level education. These two teachers will look at the four arguments with different lenses, rationalizing differently the relevance and aims of science. This is important as there is not just one argument that by itself justifies school science, as all the others have good counter-arguments (Osborne & Dillon, 2010). All the arguments are relevant for science education and emphasis on one or the other depends on the level and nature of the science subject being taught. Nonetheless, one cannot hide the relevance of the economic argument in the present time; this argument has brought forth and emphasis on science outreach.

Science Outreach

Science Outreach is often linked with the economic argument. Science Outreach can be defined as *"the act of seeking and reaching out to the nation's youth and encouraging them to consider the STEM (Science, Technology, Education and Mathematics) disciplines as a career choice"*, by providing a way to enhance students' interest in, attitudes toward, and understanding of science (Digas *et al.*,2007, p.25).

Dr. Edward Walsh, founding president of the University of Limerick, gave his insight about science outreach (Independent, 2008):

> *"There are many people conducting very exciting PhDs. If the unions will permit it, why not offer them an attractive rate to come into classrooms and share some of their findings?"*

Well, the economy of today does not allow us to think of paying PhD students to do science outreach, but the matter of fact is that Universities and other organizations (technology companies for instance) are becoming much more aware of the role they need to have in engaging students with science. The In 2009 the editor of *Neuroscience* dedicated an editorial to it (NeuroScience, 2009), and stated:

> *"Recently, many more scientists have become involved in attempts to improve public science education. Programs designed either to provide basic science content and creative science teaching tools to teachers or to encourage scientists to form partnerships with their local schools have mushroomed"*

The editor of *Neuroscience* is referring here to the reality in the USA, but Ireland is not that different. If you visit the websites of science departments of various Irish Universities you discover amazing science outreach work, which is being developed throughout the country. Complementary to this, organizations like Engineers Ireland and several major enterprises present in Ireland are also developing very interesting work in science outreach. These informal science outreach programs are then a reality in a great number of primary schools and the formal sector of science education cannot ignore it. Historically the informal sector and the formal sector did not cross. Scientists, engineers and others who developed outreach activities usually did not engage with educational researchers (Stocklmayer *et al*., 2010). Fortunately the tide is turning, and research is now being performed in the crossing between these two sectors (Thiry *et al*., 2008). This can only benefit both sides. As the European Union report *Science Education Now* (European Commission, 2007) states:

> *"Community support can be instrumental, not only in accelerating the pace of change, but also in enriching the newly developed techniques. The participation of all stakeholders, including experts of SE, teachers, students, parents, scientists, engineers and their organizations, including schools, teacher and parent organizations, universities, research institutes, Science museums, Science centres, firms and local authorities is a key factor for the success"* (p.18)

So, in the next few years science outreach will probably become an even more present reality in schools, which can assist science teachers in engaging students with science.

Notwithstanding the positive effects it can have, of course science outreach is not a perfect solution and it will not fix all the issues that science education faces. Science outreach developers are well aware of that (Stocklmayer *et al*., 2010, NeuroScience, 2009). What they can be is a catalyst regarding the economic argument and help bring enthusiasm for science and science careers into schools.

Final thoughts

It is important for a teacher of science (whether a primary or post-primary teacher) to recognize the different roles of science education. Students often ask 'why are we learning this?', 'why is this relevant?' and it is vital to answer these questions, in order to defend school science. It is also crucial to understand the different decisions that teachers need to make and how they need to be contextualized for different realities: the different areas of science taught; the different students taught; or the specific context of different schools. And now, with science outreach being a core activity for so many third level institutions, teachers and students can and should benefit from the initiatives they now offer to schools.

References

Digas, D. E., Grote, J. G., Fielding, J., Jones, K. W., Jenkins, L. C. & Leon Turner, I. (2007) Creating scientific and technical talent through educational outreach. *Proc. SPIE* 6668, Novel Optical Systems Design and Optimization X, 666809

Dublin City of Science (2012). *Focus on Careers as Science Olympics comes to Ireland*. Available at: http://www.dublinscience2012.ie/2011/07/focus-on-careers-as-science-olympics-comes-to-ireland/

European Comission. (2011) *Progress towards the common european objectives in education and training*. U. A. Directorate-General for Education and Culture, Ed.

European Commission (2007) *Science education now a renewed pedagogy for the future of Europe*. Luxembourg: Directorate-General for Research. European Commission. Science, Economy Society

Independent (2008) *Primary school is key to driving take-up of maths and sciences*. Available at: ww.independent.ie/business/irish/primary-school-is-key-to-driving-takeup-of-maths-and-sciences-26470959.html

Ireland. Department for Jobs (2011). *Strategy for Science, Technology and Innovation Indicators - December 2011*. [Online]: Forfas. Retrieved from: http://www.djeLie/publications/science/2011/SSTI_Indicators_December2011.pdf

Neuroscience Editor (2009) Encouraging science outreach. *Nat Neurosci,* 12(6)**,** 665-665

Osborne, J. & Dillon, J. (2010) *Good practice in science teaching: What research has to say*. Buckinghamshire, UK: Open University

Stocklmayer, S. M., Rennie, L. J. & Gilbert, J. K. (2010) The roles of the formal and informal sectors in the provision of effective science education. *Studies in Science Education,* 46(1)**,** 1-44

Thiry, H., Laursen, S. L. & Hunter, A. B. (2008) Professional development needs and outcomes for education-engaged scientists: A research-based framework. *Journal of Geoscience Education, 56(3), 235-246.*

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A Periodic Table of Limericks #3

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Lithium, Li

Light little lithium, the metal with mettle,
Keeps much of our mobile-powered world in good fettle;
Found in sea and in soil,
Floats on water and oil,
Has often helped many's the troubled mind settle.

Notes:

Light little lithium, the metal with mettle,

Lithium is the lightest of all the metal elements, and the smallest of the Alkali group metals.
[mettle: noun *vigour, stamina; strength of spirit or temperament]*

Keeps much of our mobile-powered world in good fettle;

Lithium's lightness helps to make lithium ion batteries the power source of choice for so many of our mobile electronic devices such as phones, laptops, notebooks, etc.

Found in sea and in soil,
Floats on water and oil,

Lithium metal is so light that it floats on the surface of water. In fact, it whizzes about frantically and shrinks in size as it reacts with the water to produce hydrogen gas (H_2) which sometimes ignites due to the heat liberated during the reaction.

Has often helped many's the troubled mind settle.

Though tiny, the lithium ion (Li^+) - in the form of lithium carbonate (Li_2CO_3) - is a powerfully effective mood stabiliser for those with bipolar disorder.

Assessment for Learning in the Chemistry class

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The Assessment Reform Group (2002) gave this definition of assessment for learning:
'Assessment for Learning is the process of seeking and interpreting evidence for use by learners and their teachers to decide where the learners are in their learning, where they need to go and how best to get there'.

You don't fatten the pig by weighing it!

Figure 1: Summative assessment will not enhance the pupils' learning in the way formative assessment will.

There is a time and a place for both summative and formative assessment in the classroom. Assessment **for** learning and Assessment **of** Learning are interrelated and complementary approaches. Both approaches should be used simultaneously to give an overall picture of how the learner learns and what point they have reached in their learning. Table 1 highlights the main differences in Formative (Assessment **for** Learning) and Summative (Assessment **of** Learning).

Table 1: Summary of the differences between Formative and Summative assessment (Cruz, 2013)

	Formative	**Summative**
Relation to Instruction	Occurs during instruction	Occurs after instruction
Frequency	Occurs on an ongoing basis (daily)	Occurs at a particular point in time to determine what students know
Relating to grading	Not graded – information is used as feedback to students and teachers, mastery is not expected when students are first introduced to a concept	Graded
Students role	Active engagements – self assessment	Passive engagements in design and monitoring
Requirements for use	• Clearly defined learning targets that students understand • Clearly defined criteria for success that students understand • Use of descriptive versus evaluate feedback	• Well designed assessment blue print that outlines the learning targets • Well designed test items using best practice
Examples	Examples include: interviews, evidence from work samples, paper and pencil tasks	Examples include: state assessment, end of unit assessment, common assessment
Purpose	Designed to provide information needed to adjust teaching and learning while they are still occurring	Designed to provide information about the amount of learning that has occurred at a particular point.

Assessment for Learning is not something that is extra or "bolted on" that we have to do. Rather, it neatly integrates with our existing classroom practice.
Assessment for Learning involves the following key actions:

- Sharing learning intentions;
- Sharing and negotiating success criteria;
- Giving feedback to pupils;
- Effective questioning; and
- Encouraging pupils to assess and evaluate their own and others' work.

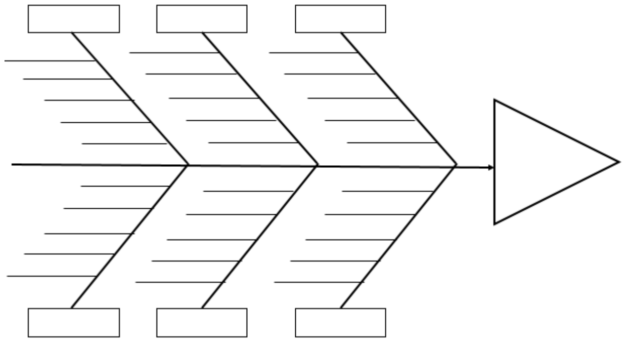
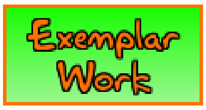
(Northern Ireland Curriculum, 2012)

There are many strategies that the Chemistry/Science teacher can use to include Assessment for Learning (AfL) in their lessons. The following article will outline a number. Table 2 outlines five categories of approaches and examples of each approach.

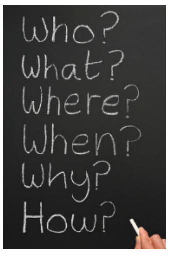
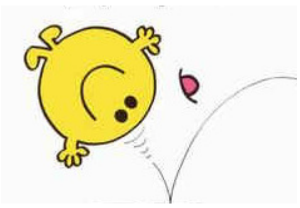
Table 2: Strategies to incorporate Assessment for Learning into the Chemistry/Science lesson

Paper based AfL Strategies	**Question based AfL Strategies**	**Gesture type AfL Strategies**	**Reflection type AfL Strategies**	**Digital AfL strategies**
~ One-Sentence Summary ~ Graphic Organisers ~ Exemplar Work ~ Minute Paper ~ Mid unit assessment ~ Student marking scheme ~ Peer assessment	~ Comment-only marking ~ X and Y ~ Students Write/Ask Questions ~ Invert the Question ~ Questioning ~ Bouncing ~ Wait-time	~ Traffic Lights ~ Thumbs Up ~ Smiley Faces	~ 2 stars and a wish ~ Post It ~ Feedback sandwich ~ KWL ~ Tell your neighbour ~ Muddiest point	~ Socrative ~ Exam time

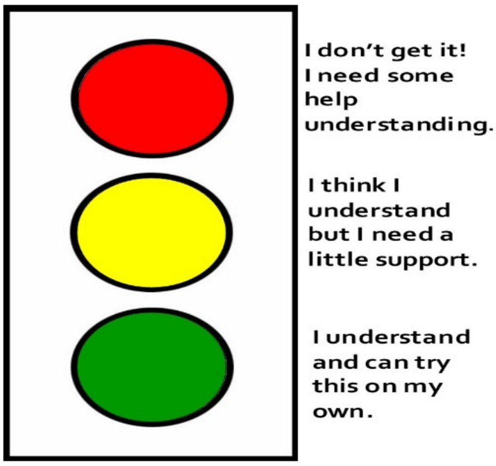
Paper Based AfL Strategies:

Strategy Type	Description
One-Sentence Summary	Students write a sentence summarising their knowledge of a topic. The sentence could have to include who, what when, why, how, where etc. The sentences could then be peer-assessed and then re-drafted.
Graphic Organisers	Graphic organisers can be used to help your students classify ideas and communicate more effectively. **<u>Example</u>**: A Fishbone  Many more graphic organisers can be found at: http://www.pdst.ie/node/2827
Exemplar Work 	<u>Approach 1</u>: When setting students a piece of work, show them examples that make it clear what it is they are being asked to do – and what they need to do in order to meet the assessment criteria. <u>Approach 2</u>: Students could mark exemplar work using the assessment criteria. Students could look at a poor , a medium and an excellent answer and recognise the features of the answer that make one more powerful than the other. This will help model what is being asked for and how it relates to the process of assessment
Minute Paper	Students identify the most significant (useful, meaningful, unlikely) thing they have learnt during the lesson or unit.
Mid unit assessment 	Having an assessment at the end of a unit may not provide time for you to go over areas students have struggled with, or in which there are general misconceptions. Timing assessment during a unit (i.e. lesson 5 of 7) allows time to review, reflect and revisit. It also gives the teacher an opportunity to focus explicitly on areas of weak understanding supported by evidence.
Student marking scheme 	Ask students to produce their own mark-schemes either individually or in groups. They can then peer- or self-assess work in accordance with these schemes. By taking part in the process of assessment, students gain a deeper understanding of topics, the process of assessment and what they are doing in their own work. This helps to make them more aware of 'what learning is' and thus see their own learning in this way.
Peer assessment	Students mark each other's work according to assessment criteria. Encourages reflection and thought about the learning as well as allowing students to see model work and reason past misconceptions. Opportunities to do this throughout individual lessons and schemes of work.

Question based AfL Strategies:

Strategy Type	**Description**
Comment-only marking	Comment-only marking provides students with a focus for progression instead of a reward or punishment. Comments should make it clear how the student can improve.
X and Y 	Ask students why X is an example of Y e.g. Why is Manganese Dioxide an example of a catalyst? Questioning in this way avoids factual recall and asks for the underlying reasoning to be made explicit.
Students Write/Ask Questions 	Students should write or ask questions. This can be done in a number of ways. For example – • About what they would like to know on a new topic • To ask the teacher or other students in order to assess their learning • To demonstrate their learning/misconceptions/areas they would like to further explore The classroom could have a question box where students drop questions at the end of a lesson.
Invert the Question 	Instead of asking a question that requires factual recall, invert it to request explicit reasoning. e.g. 'Is Gold an element?' becomes 'What does it mean for a substance to be an element?'
Questioning 	• Ask 'open' questions – to promote thinking • Increase 'wait time' • 'No hands up' • Allow students to confer • Acknowledge and give feedback • Have students formulate questions • Use of seen questions
Bouncing 	Bounce answers around the room to build on understanding and have students develop stronger reasoning out of misconceptions. e.g. "Sean, what do you think of Sarah's answer?" "Colm, how could you develop Sarah's answer to include more detail?" "Fiona, how might you combine all we've heard into a single answer?"
Wait-time 	Wait time allows students time to think and therefore to produce answers. Also, not everyone in the class thinks at the same speed or in the same way – waiting allows students to build their thoughts and explore what has been asked. 2 types of wait time – i) Teacher speaks and then waits before taking student responses. ii) Student response ends and then teacher waits before responding. This gives the student space to elaborate or continue – or for another student to respond.

Gesture type AfL Strategies:

Strategy Type	Description
Traffic Lights	
Thumbs Up 	Check class understanding of what you are teaching by asking them to show their thumbs. Thumbs up = I get it Thumbs half way = sort of Thumbs down = I don't get it
Smiley Faces	Students draw smiley faces to indicate how comfortable they are with the topic. 

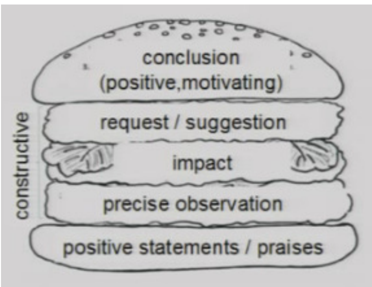
Reflection type AfL Strategies:

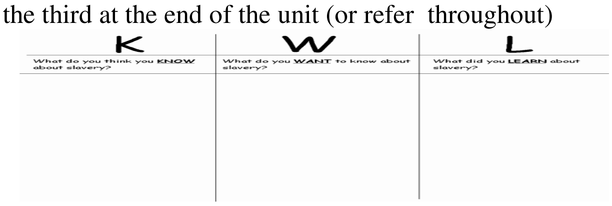
Strategy Type	Description
Post It 	Use post-it notes to evaluate learning. Groups, pairs or individuals can answer: • What have I learnt? • What have I found easy? • What have I found difficult? • What do I want to know now?

<table>
<tr><td></td><td></td></tr>
<tr><td>Tell your neighbour
</td><td>Students ‘tell their neighbour’ as a means of articulating their thoughts.
- Ask a question, give thinking time and then ask students to tell their neighbour their thoughts.
- Tell students what the new topic is and then ask them to tell their neighbour everything they know about it</td></tr>
<tr><td>Muddiest point
</td><td>Students write down one or two points on which they are least clear. This could be from the previous lesson, the rest of the unit, the preceding activity etc. The teacher and class can then seek to remedy the muddiness</td></tr>
<tr><td>2 stars and a wish

</td><td>For peer assessment, ask students to give two stars and a wish.

Two stars = 2 things that are good about the piece of work

A wish = something they can improve to make it even better</td></tr>
<tr><td>Feedback sandwich

</td><td>Feedback can be delivered in different ways, two feedback ‘sandwiches’ are –
i) Positive comment
Constructive criticism with explanation of how to improve
Positive comment
ii) Contextual statement – I liked….because….
Now/Next time… Interactive statement e.g. a question based on the work</td></tr>
<tr><td>Strategy Type</td><td>Description</td></tr>
<tr><td>KWL</td><td>At the beginning of a topic pupils create a grid with three columns –

They begin by brainstorming and filling in the first two columns and then return to the third at the end of the unit (or refer throughout)

</td></tr>
</table>

Digital AfL Strategies:

Strategy Type	Description
*Socrative**	Socrative is a student response system Similar to 'clickers' and 'the ask the audience' part of who want to be a millionaire
*Exam time**	Pupils can create electronic mind maps for individual topics

**These applications will be discussed in a future article*

References:

Assessment Reform Group (2002) '*Assessment for Learning: 10 Principles',* University of Cambridge Faculty of Education.
Cruz, J (2013) 'Informal vs. Formal Assessments: Tests are not the only end-all-be-all of how we assess.' http://jeffreymdelacruz.wordpress.com/category/eds-113-principles-and-methods-of-assessment/ (accessed 21/10/2013).
Northern Ireland Curriculum, 2012 'Assessment for Learning for Key Stage 1 & 2' http://www.nicurriculum.org.uk/docs/assessment_for_learning/training/afl-guidance-ks12.pdf (accessed 21/10/2013).

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Diary

2015

ASE Annual Conference
7-19 January
Reading, UK
http://www.ase.org.uk/conferences/annual-conference/

4th New Perspectives in Science Education
20-21 March
Florence, Italy
http://conference.pixel-online.net/NPSE/

ISTA Conference
27-29 March
UCC, Cork
www.ista.ie

1st International Baltic Symposium on Science and Technology Education (BalticSTE2015)
15-18 June
Siauliai, Lithuania

9th Chemistry Demonstration Workshop
June – date tbc
Sarah.hayes@ul.ie

6th Eurovariety 2015
29 June – 1 July
Tartu, Estonia

41st ChemEd
28 July – 1 August
Kennesaw, Georgia, USA
http://ccpe.kennesaw.edu/chemed/

11th ESERA
Science Education Research: engaging learners for a sustainable future
31 August – 4 September
University of Helsinki, Finland
www.esera2015.org

45th IUPAC World Chemistry Congress
9 - 14 August
Busan, S. Korea (KR)

ChemEd-Ireland
17 October
UCC, Cork
d.kenendy@ucc.ie

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

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The Instrument Makers No. 6: Anders Celcius (Celsius) (15/04/1701 - 21/03/1744)

Adrian J. Ryder tutorajr@gmail.com

Oil painting of Anders Celsius. Painting by Olof Arenius (1701 - 1766).
The original painting is placed in the astronomical observatory of Uppsala University.

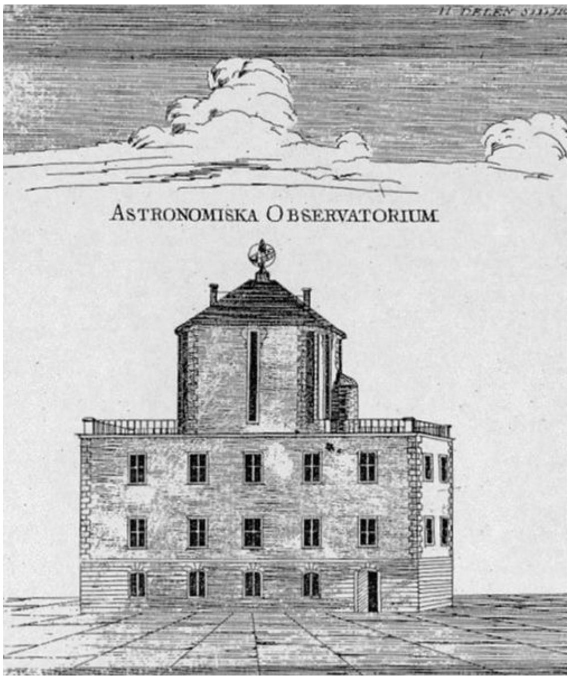
Anders Celcius came from a strong academic background. His father, Nils (1658 – 1724) was professor of Astronomy in Uppsala University in Sweden from 1718 to 1724 and both of his grandfathers held professorships there as well. His mother, Margaret Spole, who married Nils in 1691, was herself a daughter of Professor of Astronomy Anders Spole and Marta Lindelia. Information on Nils' children is sparse but Anders had at least one sister, Sara, who was to marry Anders' assistant Olaf Hjorter (1696 – 1750) in 1742. Anders himself was never to marry.

As a child Anders showed anability for mathematics beyond his years. At twelve he managed to solve all the mathematical problems in a university text book. This mathematical prowess was to serve him well later on in his chosen career.

Anders became Professor of Astronomy in Uppsala University in 1730 following the death of Professor Erik Burham (1692 – 1729), who had succeeded Nils Celcius. But finding that the equipment available was old and obsolete, two years later Anders went on a 'Grand Tour' from 1732 to 1735, visiting and working in observatories in Berlin, Venice, Bologna Rome, Paris and London. On the way he acquired the latest in equipment for use in Uppsala. While in Nuremberg in 1733 he published a collection of some 316 observations of the Aurora Borealis made there by himself and other workers. Later, in Paris, he persuaded the French Academy to finance an expedition to the far North of Sweden. This expedition, under the leadership of the French astronomer Pierre-Louis Moreau de Maupertius (1698 – 1759), took place in 1736, with Anders himself being one of the party. Anders was commissioned by de Maupertius to go to London to obtain a zenith sector from Alexander Graham, the leading instrument maker of the period. The other four members of the expedition were Alexis Claude Clairaut (1713 – 1765), Charles Etienne Louis Camus (1699 – 1768), Pierre Charles le Monnier (1715 – 1799) and Abbe Pierre Louis Moreau de Outhier (1694 – 1774). The aim of the expedition was to measure the length of a degree of arc close to the Pole and to compare this with findings from a similar expedition to Peru (present-day Equador). The findings showed that Issac Newton's (1642 – 1726) belief that the Earth was a flattened ellipsoid was correct.

France rewarded Anders with an annual state pension of 1,000 livres which left him comfortably off. However the rigours of the rough life on the Lapland expedition and his nocturnal observations weakened him physically, so that he developed tuberculosis from which he was eventually to die.

On his return to Uppsala Anders found that his participation in the expedition had made him famous throughout Sweden and he set about getting funding from the Swedish authorities to build a proper observatory for University use. A former Professor of Astronomy in Uppsala, Anders Spole (1630 – 1699), who became Professor in Uppsala in 1679, had an observatory built on his roof top. But this was destroyed, together with his papers and equipment, in the great fire of May 16th 1702, in which more than three-quarters of the town was burned to the ground. The new Observatory opened in 1741 with Anders Celcius as its Director and readings began to be systematically made and recorded. Anders pioneered the measurement of the magnitude of stars using a photometric method. One brilliant piece of apparatus that he devised was a set of identical transparent glass plates, which were placed on top of each other one by one until the star disappeared from view. Some 25 plates were required to extinguish the light from Sirius, the brightest star in the sky. The mean error of this simple equipment was a mere 0.4 magnitude.



The house of Anders Celsius with his observatory on the roof, from a contemporary engraving.

The Observatory building may still be seen on Svartback Street. It is easily seen as it is situated at an angle. Anders lived in the building, and as a lifelong bachelor he did not need more space.

Another part of the duties of the Astronomical Department was the making of geographical measurements. Anders carried out many of these for the Swedish general map and was the first to observe that the land of the Nordic countries was slowly rising above sea level. This rise had been going on from the melting of the last ice age. Anders concluded, wrongly, that the rise was due to the seas evaporating and not the land itself being forced upwards.

As part of the work of the Observatory meteorological readings were also taken. In 1742 Anders devised a new temperature scale, which he called a centigrade one, finding the Fahrenheit scale to be too unwieldy for general use. His thermometer was to be commonly known as the Swedish thermometer. Anders' two fixed points were those of water at its freezing point and its boiling point under a pressure of one atmosphere. Curiously he settled on 100^o for the freezing point and 0^o for the boiling point. Following his death, Carl Linnaeus inverted the scale, which was then in use unchanged until 1954. In that year the General Conference of Weights and Measures decided to standardize various units, that of Celcius being one. They decided to define Celsius temperature as Kelvin minus 273.15.

The first of the two new reference points was the triple point of water which was defined to be 273.16 Kelvin and 0.01°C.
(*The triple point of water is the temperature and pressure at which water exists simultaneously as a solid, liquid and gas. The triple point can be measured accurately and precisely, so it was a superior reference to the freezing point of water.*)
The other fixed point, absolute zero is the lowest temperature possible for matter, where it has minimum entropy. It is -273.15^o C. The new scale was called the Celsius scale in honour of Anders.

Anders published most of his findings in the publications of the Royal Society of Sciences in Uppsala. This is the oldest of the Swedish scientific societies, having been founded in 1710, and Anders served as its secretary from 1725 to his death in 1744.

In 1739 Anders strongly supported Linnaeus and five others in the formation of the Royal Swedish Academy of Sciences in Stockholm and he was elected a member of the Academy at its first meeting. In passing it should be noted that the name of the Academy was that suggested by Anders.

Not just satisfied to with working in Astronomy Anders used his interest in mathematics to produce a book in 1741, *Arithmetics for the Swedish Youth*, which became a popular publication.

Anders actively supported the proposal to reform the Julian calendar in Sweden to the Gregorian but did not live to see its implementation in 1753.

Anders was aged only 42 when he died of tuberculosis. He was buried in the next grave to that of his grandfather, Magnus Celcius, in the church at Gamla Uppsala which lies some five km north of the centre of Uppsala.

On his death Olaf Hjorter inherited Anders' very extensive astronomical library and collection of astronomical instruments. Olaf donated the collection and instruments, together with a sum of 6,000 crowns to the Uppsala Observatory in 1747.

References

http://www.astro.uu.se/history/Celsius_eng.html
http://en.wikipedia.org/wiki/Anders_Celsius
http://www.notablebiographies.com/Ca-Ch/Celsius-Anders.html
http://www.tekniskamuseet.se/1/2245.html
http://chemed.chem.purdue.edu/genchem/history/celsius.html
http://sv.wikipedia.org/wiki/Celsius_(sl%C3%A4kt)

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AACT: New US chemistry teachers' association

C&EN, 1/9/14

The American Chemical Society (ACS) launched on Sept. 1st. 2014 the American Association of Chemistry Teachers (AACT). There is a large association of science teachers in the USA – the National Science Teachers' Association, NSTA – but nothing specifically for chemistry teachers. There are estimated to be 30-40,000 chemistry teachers in the USA(!), of whom ~1,800 are members of the ACS. (www.teachchemistry.org)

The AACT subscription costs $50 and will give chemistry teachers access to teaching resources and a subscription to *CheMatters* and *Chemistry Solutions.*

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Drive to recruit chemistry specialists in UK

The Royal Society of Chemistry (RSC) in the UK has launched a campaign to increase and support the number of specialist chemistry teachers in English schools. The scheme will later be extended to Wales and N. Ireland.

The move is based on surveys which show:

- One-third of secondary-school chemistry teachers do not have a chemistry degree.
- A survey of a sample of primary schools, only 6 per cent were found to have a science subject leader with a science degree.

Bursaries of £25,000 will be offered to encourage suitably qualified graduates to train as chemistry teachers.

http://www.rsc.org/globalassets/04-campaigning-outreach/inspring-the-next-generation/specialist-teachers-parliamentary-briefing.pdf

A detailed report on this issue is available at: www.rsc.org/AboutUs/Campaigns/science-teaching/index.asp

Learn Chemistry

If you haven't already checked out the RSC's Learn Chemistry web portal for chemistry teaching resources (http://www.rsc.org/learn-chemistry), then you should do so.

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Stop press:
RSC Education Coordinator – ROI

The host of the ROI's Royal Society of Chemistry's Education Coordinator will be the Department of Chemistry, Trinity College, Dublin. This post will be advertised so the person will be in post by the end of 2014. Dr. Stephanie Nelson has been appoined as the RSC's Education Coordinator for N. Ireland, and she spoke at ChemEd-Ireland 2014. Dr Angela McKeown is the Education Programme leader for Ireland.

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Parabens as preservatives in personal care products

Nicole Garner[1], Antje Siol[2] & Ingo Eilks[1]

[1] Institute for Science Education, University of Bremen, Bremen, Germany
[2] Institute for Environmental Research and Sustainable Technologies, University of Bremen, Bremen, Germany

Abstract

Parabens are widely used as preservatives in personal care products, but are also controversial. This paper discusses the chemistry and effects of parabens and provides a series of experiments, with which students can inquire into the effects of parabens as preservatives in cosmetics.
Keywords: preservatives, cosmetics, parabens, structure-property-relations

Introduction

Many people use skin creams and body lotions almost every day. The skin creams are often packed in small pots. For use, the cream is applied with the fingers and we do not wash our hands every time before creaming our skin. Therefore, germs from the hand get into the cream pots. Inside the pots, the conditions for rapid microbial growth of the germs are optimal: the creams often contain a lot of water and are kept in warm bathrooms. That is why special measures must be taken so that the cream does not spoil. Preservatives are added to nearly every skin cream or body lotion. Without preservatives, the germs would accumulate in the cream and spread, which finally would cause skin problems or even dermatitis.

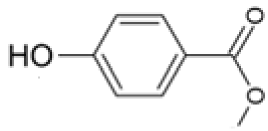
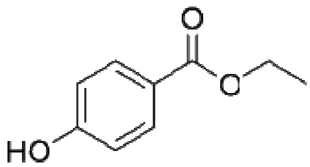
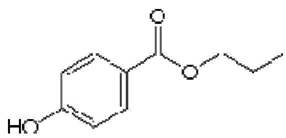
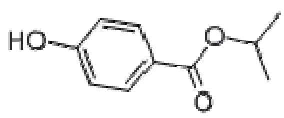
Parabens are one of the most common preservatives used in cosmetic products. They are used in a wide variety of products including shampoos, lotions, deodorants, scrubs and eye makeup. Parabens are, however, critically perceived and discussed in the public and in the media. Reports are available in newspapers about the estrogenic effects of parabens, which are then connected to speculations on fertility problems in men and the promotion of breast cancer in women (e.g. *The Guardian*, 2009; *DailyMail*, 2012).

This paper discusses the chemistry of parabens and the controversy about its use. The paper provides also a series of experiments through which students can inquire into the chemistry of parabens and their use as preservatives.

Structure, properties and effects of parabens

Parabens are homologous esters of para-hydroxybenzoic acid. The various representatives of this substance class differ only in the structure of their alkyl radicals (see Table 1).

Table 1: Structures and properties of various parabens

Name	Structure	Properties
Methylparaben *Methyl p-hydroxybenzoate*		$C_8H_8O_3$ Solubility: 2.5 g/l pKs = 8.17
Ethylparaben *Ethyl p-hydroxybenzoate*		$C_9H_{10}O_3$ Solubility: 1.7 g/l pKs = 8.22
Propylparaben *Propyl p-hydroxybenzoate*	 	$C_{10}H_{12}O_3$ Solubility: 0.5 g/l pKs = 8.35

…

The antimicrobial activity of parabens were first described in the 1920 by Theodor Sabalitschka (Böhm & Sabalitschka, 1940, 1941). Since that time, parabens became used worldwide in foods, cosmetics, detergents and medicines to protect them against molding.

Parabens are white, odourless, fine crystalline substances. A strong taste occurs at concentrations above 0.08%. This taste is often described as metallic. Use in food in higher concentrations is therefore limited. However, parabens are odourless, do not discolour cosmetic products and are inexpensive to manufacture. Parabens are effective preservatives that work well in a wide pH-range from 4.5 - 7.5. Parabens are quite resistant against hydrolysis and are stable in the temperature ranges required for the production of cosmetics. The good stability against external conditions, combined with quite low costs of production, explains why parabens are so commonly used.

Usually, combinations of two or three parabens are used for preservation. Concentrations of at least 0.4% as a single agent and a maximum of 0.8% in the sum of all parabens are usual. Microbial growth takes place only in aqueous phases. Therefore, the water solubility of the preservatives and their distribution in water / oil emulsions are crucial for their antibacterial activity. The solution behaviour may be described by the "*octanol/water distribution coefficient*" (log K_{ow} or log P; Leo, Hansch & Elkins, 1971). The higher this value, the better a substance dissolves in oils and non-polar solvents. At the same time water solubility is decreasing. The log K_{ow} value increases in parabens with the number of carbon atoms in the alkyl chain. In oils and organic solvents, the solubility increases with increasing chain length (Merck Millipore, 2014). However, the water solubility and preservative effect decreases simultaneously. Overall, parabens are slightly soluble in water (log K_{ow} > 1.9; c < 2.5 g/L at 25 °C). But this solubility is sufficient to achieve the preservative effect.

Parabens can interfere with the metabolism of microorganisms. The mechanism of action is very varied and nonspecific. Although an exact cause-and-effect relation for the mode of action has not been established, studies showed various effects of parabens (Soni, Taylor, Greenberg and Burdock, 2002, Davidson, Sofos and Branen, 2005). For use in the school context, simplified mechanisms of preservative effect of parabenes can be suggested: Due to their solution behaviour, parabens can pass through cell membranes and then interferes with the protein biosynthesis in the cells. The parabens react with free amino acids with the elimination of water (Figure 1). Then, these amino acids are no longer available in sufficient quantity for the protein biosynthesis. A further effect of the parabens is based on the coupling with the two acidic amino acids glutamic acid and aspartic acid. The free carboxyl group within a protein chain reacts with a paraben. The reaction is analogous to the reaction between parabens and free amino acids. Thus, the correct folding of the protein is prevented. Consequently, the three-dimensional structure of the enzyme cannot bind to receptors. Defective enzymes can inactivate the metabolism of a bacterial cell and cause the cell to die.

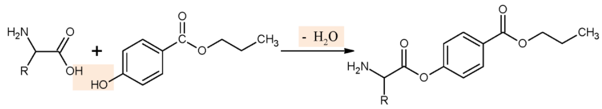


Figure 1: Reaction between an amino acid and propyl paraben

The controversy around parabens in cosmetics

Most people in the Western world can come into almost daily contact with parabens. Parabens are applied in cosmetics or ingested with food or pharmaceuticals. A study from the US showed that parabens are to be found in nearly all urine samples from U.S. adults, regardless of ethnic, socioeconomic or geographic backgrounds (Ye, Bishop, Reidy, Needham and Calafat, 2006).
The effect of parabens on the human body is not without controversy. Parabens have been repeatedly suggested as causing allergies. The allergenic potential of parabens is proven. But, the incidence of allergies caused by parabens varies depending on the study. Some studies identified the allergenic potential of parabens to be rather low, ranging from 0 to 4.2 % (Elder, 1984, Rietschel and Fowler, 1995, Menne and Hjorth, 1988, Thyssen et al., 2010). However, there are also studies reporting that there are no sensitizing effects by parabens on normal skin. Sensitization only occurred if the relevant skin areas were already damaged or broken (Soni et al., 2002). That also other preservatives may cause allergies, and sometimes even stronger, is seldom discussed

in the context of criticizing parabens (Thyssen *et al.,* 2010).

In recent years, there has also been dispute about possible endocrine-disrupting effects of parabens. Parabens have an estrogen-like structure. Studies showed a weak estrogenic activity of parabenes (Byford *et al*., 2002). It was suggested that parabens disrupt hormones of male fetuses and young children. In the worst case, fertility may be adversely affected (Darbre and Harvey, 2008). However, the hormonal activity of butylparaben was determined to be approximately 100,000 times weaker than estrogen (Cashman and Warshaw, 2005) and the estrogenic activity even decreases for derivatives with a shorter alkyl group. The authors concluded that parabens pose no health risk if the parabens with short alkyl-groups are consumed in low level doses, as is usual in cosmetics.

Nevertheless, there were also alarming studies describing that parabens were found in female breast cancer tumors. It was suggested that the parabens would have promoted the growth of tumors because of their similarity to estrogen (Darbre *et al*., 2004; Harvey and Everett, 2004). However, these studies are even controversial in themselves, because the conditions of the study were not sufficiently described. Additionally, studies with opposite results also exist (Mirick, Davis and Thomas, 2002). The majority of the scientists today do not see any proved causal relationship between the use of parabens and the development of breast cancer.

In conclusion, not all potential health effects of parabens on the human body are fully understood today. In 2005, a safety assessment of parabens concluded that cosmetics containing parabens do not pose a health risk. The European Scientific Committee on Consumer Products (SCCP) agreed with this assessment. Taking into account the diversity of studies, the European Commission put a paraben-maximum of 0.4% in cosmetic products (Scientific Committee on Consumer Products, 2006). However, in some European countries, such as Denmark, the use of parabens as preservatives was completely banned. Although in most other countries the use of parabens is still legal, industry started reacting to the bad reception parabens have in public debate. Although at least methyl and ethyl paraben are considered as being safe, an increasing number of cosmetic producers started changing the recipes of their products and launched labels on their products advertising them as "parabens free". However, most of the paraben-free cosmetics contain preservatives. Alcohols, sorbate or grapefruit seed extract are used. Most these preservatives are also considered as being safe on the same basis as it is suggested for parabens. But this does not apply for all. There are products using methylisothiazolinone instead of parabens. Research suggests that methylisothiazolinone has a higher allergy risk than the parabens (Lundov, Thyssen, Zachariae and Johansen, 2010), but unlike for parabens this is not yet critically discussed in the public debate.

Inquiring into parabens and their effects

Parabens are also suitable for the discussion of experimental and analytical methods (Remcho, McNair and Rasmussen, 1992; Bender, Booth and Walker, 2013). The experiments described below were developed for the senior cycle in secondary education but might also be applied in the Irish Transition Year. However, the question of parabens using only a selection of the suggested experiments might also be applied in the junior secondary high school level (Belova, Marks and Eilks, 2014; Garner, Siol and Eilks, 2014)

The effect of parabens and selected alternatives in a self-made cream can be determined experimentally. Simple, qualitative trials may also be carried out as well as more complex quantitative analyses. The subject provides students with the opportunity to question an everyday product critically. Depending on the age of the students, the discussions and selected aspects of the studies discussed above can be involved (Coleman, 2009).

As a reagent for some of the tests, a simple skin cream can be produced in the laboratory: 3 g of salad oil, 1 g of a structure provider and 2 g of an emulsifier (lecithin or tegomuls) are heated to 70 °C. In a separate beaker, 50 mL of water are also heated to 70 °C. Subsequently the aqueous phase is added to the fat phase and the emulsion is stirred until cooling. The skin cream needs initially to be free of preservatives. In connection to the experiments, the preservative and skin care substances can be added later to enhance the cream.

1. Extraction of parabens from creams

3 g of a commercial cream is heated and stirred in a solution of 30 mL ethanol and 1.5 mL methanoic (formic) acid (c = 4 mol/L) to 70° C. The result is a milky solution that is clarified by the addition of 2 mL Carrez I and II. Carrez I is a solution of potassium ferrocyanide (15 g solved in 10 mL water) and Carrez II a solution of zinc sulfate (30 g solved in 100 mL water). The result is potassium-zinc hexacyanoferrate(II) ($K_2Zn_3[Fe(CN)_6]_2$), which binds the colloidal proteins. The solution is allowed to stand until phase separation. The supernatant liquid is filtered off (de Kruiff, Schouten, Rijk and Pranoto-Soetardhi, 1989 Agilent Technologies, 2010). Parabens can be detected with usingthin-layer chromatography.

2. Detection and differentiation of parabens by thin-layer chromatography (TLC)

Parabens can be easily identified by thin layer chromatography. The extract from Experiment 1 was applied to a silica gel plate with a fluorescent indicator F254. For comparison, the individual substances are spotted next to the extract. A solution of petroleum ether / methyl tert-butyl ether / methanoic acid (20 / 5 / 1) is used as the mobile phase for thin layer chromatography. The identification is done under a UV-lamp (254 nm). The various parabens can be separated well by this method (see Figure 2).

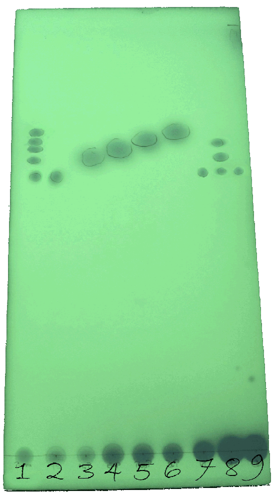


Figure 2: Detection of parabens in skin cream of various brands (7), (8) and (9). As comparison substances of 3-methoxy-benzoic acid (2), methylparaben (3) Ethylparaben (4), propylparaben (5), Butylparaben (6) and a mixture of these preservatives (1) are applied.

3. Synthesis of ethyl paraben

Ethyl paraben can be easily synthesized by an acid-catalyzed reaction of ethanol and para-hydroxybenzoic acid. 4 g of para-hydroxybenzoic acid and 100 mL of ethanol are placed in a round bottom flask and heated under reflux. 2 g of the acidic resin Amberlyst 15 is added as a catalyst. After 30 minutes, the product can be crystalized and detected by thin layer chromatography (see Experiment 2).

4. Effects of parabens and alternatives preservatives on a skin cream

An aqueous solution is produced with each of the different preservatives (methyl paraben, ethanol, potassium sorbate, benzoic acid, grapefruit seed extract, or the product from Experiment 3). The solution is mixed into the basic skin cream so that that the cream contains 0.4% of the preservative. The samples are thoroughly stirred. One sample needs to be free of preservatives as control sample. After 2, 5, 7 and 10 days, the growth of germs shows the preservative effect in comparison with the untreated sample. The test can be accelerated by keeping samples at 35-37°C in an oven.

5. Effect of parabens and alternative preservatives to yeast

½ cube (teaspoon) of baker's yeast, 2-3 teaspoons of glucose and 80 mL of warm water of about 32°C are mixed and distributed to different test tubes. Yeast activity is visible through foaming or tested for with lime water. Drops of diluted solutions of parabens and other preservatives are added and the solutions well mixed. The parabens damage the yeast cells, so that the carbon dioxide production is terminated. A non-preserved sample is used for a control.

6. Effect of parabens and alternative preservatives in an agar patch test

6 g agar-agar powder is boiled with 100 mL water. The viscous liquid is poured and cooled in Petri dishes to form agar plates. A spatula tip of the preservative-cream-mixture from Experiment 1 is put carefully with a wooden or glass rod on the agar surface. After a few days (in a warm place about 30-35 ° C after 24 h), the settlement will be considered (see Figure 3). Related rapid test systems are also commercially available (e.g. Hach-Lange, Merck, Sigma-Aldrich).

Figure 3: Experimental result of a cream-agar patch test after 10 days. Right side: paraben-containing cream, left side: paraben-free cream.

7. Solubility of parabens and their alternatives

0.1 g of the preservative is weighed as accurately as possible into an Erlenmeyer flask. Then exactly 10 mL of water are added. Stirring helps the solution process of the preservative in water. The addition of 10 mL portions of water is repeated until the preservatives is completely dissolved in water. The specific solubility is determined by the amount of water and the weighed amount of preservative. Bacterial growth takes place exclusively in aqueous environments. Therefore, the water solubility is an important parameter. Pupils are asked to investigate and compare the dissolution behavior of various parabens and their alternatives. This experiment can be carried out well with the methyl-, ethyl- and propyl-paraben, respectively. Parabens with longer alkyl groups are not suited because of their very poor solubility in water.

8. pH-values of parabens and their alternatives

Using a pH-meter or pH-paper/stick, the pH values of a cream containing a preservative (from Experiment 1) or in an aqueous preservative solution, are measured. Parabens produce neutral solutions in aqueous environments. This is a crucial advantage compared to the preserving acids, which lead to pH-values of 3 to 4.5. Acids are therefore less suitable for the preservation of cosmetics.

Summary

This paper discusses the use of parabens as preservatives in cosmetics. The experiments show that a variety of practical work is possible with parabens at the high school level. The practical work can be initiated by using advertisements for parabens-free cosmetics for motivation. However, the experiments can lead also into a discussion about the use of parabens and other preservatives in cosmetics, their controversial reception by the public, and chemistry's and public policy's answers to it. Although the chemistry of parabens is the same to all, different stakeholder groups give varying suggestions; in one country parabens are banned, while in others they are not. The students can search for the different opinions on the Internet, compare them, and make guesses about the reasons for the varying points of view. Such an approach in a very similar case has proven to be very motivating and challenging for the learners. It has potential for skill development in critical thinking and reflection on the presentation and use of scientific information in the public, as was shown by Marks and Eilks (2010) and Marks, Otten and Eilks (2010) in the case of inquiring into and reflecting on the use musk fragrances in cosmetics.

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References

Agilent Technologies (2010). Determination of preservatives in food and drugstore products with the Agilent 1120 Compact LC, online available: www.chem.agilent.com/Library/applications/5990-4377EN.pdf [March 2014].

Belova, N., Marks, R. and Eilks, I. (2014). Aufgaben für das ganze Kompetenzspektrum: Beispiel Parabene. *Prax. Naturwiss. Chem. Sch.,* 63, 21-24.

Bender, T. A., Booth, J. and Walker, E. B. (2013). Fast Analytical Separations with High-Pressure Liquid Chromatography, *J. Chem. Educ.*, 90, 1061 – 1063.

Böhm, A. and Sabalitschka, T., Manufacture of stabilized animal and vegetable fats and oils, US Patent 2.223.244 (26th November 1940).

Böhm, A. and Sabalitschka, T., Preserving Materials, US Patent 2.255.191 (9th September 1941).

Byford, J. R., Shaw, L. E., Drew, M. G., Pope, G. S., Sauer, M. J. and Darbre, P. D. (2002). Oestrogenic activity of parabens in MCF7 human breast cancer cells. *J. Steroid Biochem. Molec. Biol.,* 80 (1), 49–60.

Cashman, A.L., Warshaw, E.M. (2005). Parabens: a review of epidemiology, structure, allergenicity, and hormonal properties. *Dermatitis,* 16 (2),. 57–66.

Coleman, W. F. (2009). Molecular Models of Esters with Recognizable Odors, *J. Chem. Educ.*, 86, 1344.

Daily Mail (2012). Chemical found in deodorants, face cream and food products is discovered, online available: http://www.dailymail.co.uk/health/article-2085585/Parabens-Chemical-everyday-items-needs-investigation-scientists-discover-tumours-ALL-breast-cancer-patients.html [February 2014].

Davidson, P. M., Sofos, J. N. and Branen, A. L. (2005). *Antimicrobials in Food*. CRC Press: FL (3rd Edition).

Dabre, P. D.,Aljarrah, A. ,Miller, W. R., Coldham, N. G., Sauer, M. J. and Pope, G.S (2004). Concentration of Parabens in Human Breast Tumours. *J. Appl. Tox.*. 24, 5-13.

Darbre, P. D. and Harvey, P.W. (2008). Paraben esters: review of recent studies of endocrine toxicity, absorption, esterase and human exposure, and discussion of potential human health risks. *J. Appl. Tox.*, 28, 561-78.

Elder, R.L. (1984). Final report on the safety assessment of methylparaben, ethylparaben, propylparaben and butylparaben. *J. Amer. Coll. Tox.,* 3, 147-209.

Garner, N., Siol, A., Eilks, I. (2014). Die Konservierung von Kosmetika mit Parabenen, *Prax. Naturwiss. Chem. Sch.,* 63, 17-20.

Harvey, P. W., Everett, D. J. (2004). Significance of the detection of esters of p-hydroxybenzoic acid (parabens) in human breast tumours. *J. Appl. Tox.,* 24, 1–4.

de Kruijf, N., Schouten, A., Rijk, M. A. H. and Pranoto-Soetardhi, L. A. (1989). Determination of preservatives in cosmetic products II. High-performance liquid chromatographic identification, *J. Chromatogr. A*, 469, 317-328.

Leo, A., Hansch, C. and Elkins, D. (1971). Partition coefficients and their uses. *Chem. Rev.,* 71 (6), 525–616.

Lundov M. D., Thyssen, J.P., Zachariae C. and Johansen, J. D. (2010). Prevalence and cause of methylisothiazolinone contact allergy. *Contact Dermatitis*, 63, 164–167

Marks, R. and Eilks, I. (2010). Research-based development of a lesson plan on shower gels and musk fragrances following a socio-critical and problem-oriented approach to chemistry teaching. *Chem. Educ. Res. Pract.*, 11, 129-141.

Marks, R., Otten, J. and Eilks, I. (2010). Writing news spots about chemistry – A way to promote students' competencies in communication and evaluation. *Sch. Sci. Rev.*, 92(339), 99-108.

Menne, T. and Hjorth, N. (1988). Routine patch testing with paraben esters. *Contact Dermatitis*, 19, 189-191.

Merck Millipore (2014). Merck Safety Data Sheets (MSDS), online avaiable: http://www.merckmillipore.co.uk/ [February 2014].

Mirick, D. K., Davis, S. and Thomas, D. B. (2002). Antiperspirant Use and the Risk of Breast Cancer. *J. Nat. Canc. Inst.,* 94, 1578 – 1580.

Remcho, V. T., McNair, H. M. and Rasmussen, H. T. (1992). HPLC method development with the photodiode array detector: A laboratory experiment, *J. Chem. Educ.*, 69, 117.

Rietschel, R. L. and Fowler J. F. Jr. (1995). Dermatitis to preservatives and other additives in cosmetics and medications. In: R. L. Rietschel and L. F. Fowler Jr. editors Fisher's contact dermatitis, Williams & Wilkins: Philadelphia, pp. 266-7 (4th Edition).

Scientific Committee on Consumer Products (2006). Opinions on parabens, online available: http://ec.europa.eu/health/ph_risk/committees/04_sccp/docs/sccp_o_074.pdf [March 2014].

Soni, M. G., Taylor, S. L., Greenberg, N. A. and Burdock, G. A. (2002). Review: Evaluation of the health aspects of methyl paraben: a review of the published literature, *J. Food Chem. Tox.*, 40, 1335–1375.

The Guardian (2009). Two-year-olds at risk from 'gender-bending' chemicals, report says, online available: http://www.theguardian.com/society/2009/nov/06/health-eu [February 2014].

Thyssen, J. P., Engkilde, K., Lundov, M. D., Carlsen, B. C., Menne, T. and Johansen, J. D. (2010). Temporal trends of preservative allergy in Denmark (1985-2008). *Contact Dermatitis,* 62, 102-108.

Ye, X., Bishop, A. M., Reidy, J.A., Needham, L. L. and Calafat, A. M. (2006). Parabens as urinary biomarkers of exposure in humans. *Environ. Health Persp.*, 114, 1843-1846.

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Hands-on Climate Change!

An Inquiry-Based Workshop about the Science behind Climate Change

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Introduction

As a part of my PhD project I designed a workshop about Climate Change for holiday Science Camps. These are part of an ongoing project in Germany, and are attended by students between 12 and 16 years and last for five days.
This workshop is interdisciplinary and inquiry-based. It was mainly developed during my stay at the National Centre for Excellence in Mathematics and Science Teaching and Learning (www.nce-mstl.ie) at the University of Limerick.

Climate Change in School Science

Although the workshop was originally designed for a Science Camp and hence for a different environment than a school science lesson, it can be adapted for use in school. The design of the Climate Change workshop is based on the endeavour to prepare today's students for their life as tomorrow's citizens. This preparation includes the ability to participate actively in a democratic society, due to well informed decision-making and a habit of critical thinking.

As a society we are going to face the so called "Grand Challenges" such as an Aging Society, Food Safety and Climate Change (Jacob, 2013). These real world problems and a search for their scientific solutions will be a definite part of the future. Therefore students should be prepared for a life in a scientifically-shaped society by being informed about the science behind these problems and possible solutions.

In particular Climate Change and the scientific theories underlying it, are facing challenges concerning their public acceptance (Oreskes, 2004) – probably influenced by media reports. These reports alternate between catastrophic future scenarios and total rejection of the notion that there is Climate Change. But Climate Change, and the underlying greenhouse theory, are widely accepted among scientists (Oreskes 2004). An article about this topic, that is suitable for students, can be found in the free *Science in School* magazine (Benestad, 2007). Therefore this topic is ideal for developing a critical thinking habit about media reports. Furthermore, it shows the need for objective experimentation as a scientific method.

All in all, Climate Change is not just a very important societal problem but concurrently an actual and meaningful context for learning science. In particular it is the object of scientific research and scientific conferences right now.

Climate Change in the Irish School Syllabus

Similar to other real-life problems, Climate Change straddles many school subjects. But the science necessary to understand it is part of Chemistry in *Junior Science* (Junior Certificate Science Syllabus 2003), for example, as "Air, Oxygen, Carbon Dioxide and Water" (Section 2B). In *Senior Science* Chemistry (Leaving Certificate Chemistry 1999), "Atmospheric Chemistry" (option 1B) covers the composition of air and the Greenhouse effect. Further, objectives of the Ordinary Level Syllabus are to develop knowledge of social and environmental aspects of chemistry, as well as understanding how chemistry relates to everyday life.

Additionally, the NCCA's "*Background Paper and Brief for the Review of Junior Cycle Science*" (2013) says: *"The change from a curriculum based primarily on knowledge and content to one in which knowledge of and knowledge about science are interwoven with skills development will be a particular challenge in science."* (NCCA, 2013, p. 19). The Climate Change workshop is in line with these aspirations – moving from content knowledge to knowledge *about* science.

The Climate Change workshop also offers lots of opportunities to connect with other subjects, such as physics, biology, earth sciences and mathematics. In particular learning mathematics within this scientific context can be very inspiring but will not be a concern in this article. The focus of this article is to present student worksheets with experiments offering insights into the science behind Climate Change.

Climate Change Workshop

The Climate Change workshop is split up in three independent units called “Greenhouse Effect”, “Water-phenomena” and “Weather and Climate”. Each of these deals with the science behind phenomena closely related to Climate Change. “Greenhouse Effect” covers, for example, the Albedo effect and experiments about carbon dioxide. Rising Sea-level and changing sea-currents make up “Water-phenomena”. “Weather and Climate” includes experiments about the formation of tornados.

As mentioned above, the workshop is based on scientific inquiry (NRC, 1996), because it is proven to be a highly effective teaching method (Yager and Akcay, 2010). Furthermore, scientific inquiry gives students a chance to experience self-efficacy, an essential component for promoting interest in science (Deci, 1993). This workshop can be described as structured or guided inquiry. Thus, the experiment descriptions are not recipe-style, but emphasize variations: for example, hypotheses may be missing, be given or be given but be wrong. In some cases even the procedure is not given. Hence, students are encouraged to think *about* the experiments and expected outcomes *before* they conduct them. Even more, they are encouraged to vary an experiment or to repeat it. The German Science Camp participants very much welcomed the opportunity to repeat experiments, especially if it didn’t work in the first place. This is actually very similar to a scientist’s working habit.

Experiments about the different scientific effects behind Climate Change are the basis of every unit. Having completed these experiments and using a wordless diagram, students can deduce the explanation of scientific phenomenon themselves. This idea was introduced by Streller and Bolte (2008) in their workshop about tornados. Other learning materials about Climate Change which had an influence on this workshop are those by Eilks (2011) and Fiene (2012).

At the end a link to real life is made through “real data” gathered by international Research Laboratories as Mauna Loa at Hawaii.

The Greenhouse Effect Unit

The greenhouse effect is the main reason for Climate Change, because – simply said – the increasing amount of atmospheric CO_2 and other greenhouse gases leads to more absorption of heat energy.

As Climate Change is very present in the media, students already know a lot about it. This prior knowledge can be used initially and collected jointly. Depending on the given time, the lesson can be continued either with the Climate Change workshop or a discussion about newspaper articles with different statements about the existence and consequences of Climate Change.

The Greenhouse Effect unit itself starts with a short introduction on how to use the material. A guideline is given on how to conduct a scientific experiment, as well as some other advices. As weather and climate are closely related but different concepts, the first activity distinguishes them. The experiments then cover Air Composition, characteristics of CO_2 and other, more direct Greenhouse experiments. The workshop also includes an experiment on the Albedo effect. Albedo can be explained as the greater absorption of heat by dark and rough surfaces. As the warming of the atmosphere causes melting of ice and glaciers, more dark surface is displayed to absorb heat. This is said to enhance the Greenhouse Effect. In the Science Camp, this does connect to another workshop called “Water-Phenomena”. This is to show the complexity of the earth system.

A unit about the Greenhouse Effect wouldn’t be complete if the good side of the greenhouse-effect wasn’t mentioned: the greenhouse effect enables life on earth, as this effect is the reason for an average temperature of 16°C on earth. Without the Greenhouse Effect, life on earth would not be possible!

Experience with the Climate Change Workshop

The workshop was run and evaluated as a part of two Science Camps in Germany with 28 participants, in July 2013. Nearly 40% of the participants would rate the Science Camp with “A” and another 58% give a “B”. In accordance with this, 82% thought the Camp was “much too short” or “too short” and 98% would like to do it again.

A questionnaire was used to measure the aspects important for a satisfying environment to learn inquiry-based such as every-day relevance and authenticity (Pawek 2009). This was compared with Pawek's bigger study, which included 734 participants (see Table 1).

Table 1: Variables after the Science Camp, compared to values of Pawek (2009), numbers are normed.

		Climate Change (N=28)		Literature (Pawek 2009) (N=734)	
		$\bar{x}$	σ	$\bar{x}$	σ
Actual interest	**Emotional aspect**	0.80	0.17	.82	.16
	Aspect of value	0.87	0.12	.75	.16
	Epistemological aspect	0.63	0.20	.52	.20
Variables of laboratory	**Every-day relevance**	0.71	0.22	.68	.20
	Authenticity	0.75	0.24	.68	.18
	Active participation	0.79	0.16	.64	.19
	Openness	0.58	0.14	.65	.24
	Understand-ability	0.81	0.13	.74	.14
	Collaboration	0.77	0.17	.64	.21

The Climate Change workshop is raising interest in science, as values for "Actual interest" are high and compare well to Pawek's results. Furthermore, students felt the Workshop was authentic and relevant to their every-day life.

Additionally we interviewed all participants about their experience in the Science Camp and with the Climate Change workshop. In summary, the students had "a lot of fun", emphasising that working together was an important aspect for them. Concerning their work style, they considered themselves as "Mini-Scientists" and enjoyed "having the chance to think on our own".

Finally, it should be mentioned that this Workshop introduces a different way of learning in and about science. Therefore some time to allow familiarisation must be allowed. After this initiation, most students enjoy the openness and self-reliability of the unit.

You will find more information about Climate Change at the following websites:

http://data.giss.nasa.gov
http://www.esrl.noaa.gov
www.esa.int

References

Leaving Certificate Chemistry. (ordinary and higher levels) (1999). Dublin: Stationery Office.

Junior Certificate Science Syllabus. (Ordinary and Higher Level) (2003). Dublin.

Benestad, R. (2007): What do we know about climate? The evidence for climate change. In: *Science in School* (7), S. 49–51. Online available at http://www.scienceinschool.org/2007/ issue7/climate.

Deci, E.L. Ryan R.M (1993): Die Selbstbestimmungstheorie der Motivation und ihre Bedeutung für die Pädagogik. In: *Zeitschrift für Pädagogik* 39(2), S. 223–268.

Eilks, I. (2011): Der Klimawandel vor Gericht: Materialien für den Fach- und Projektunterricht: Aulis.

Fiene, Christiane; Siegmund, Alexander (2012): Forscherheft Klimakoffer. "Forschen und Experimentieren zum globalen Klimawandel". Heidelberg.

National Council for Curriculum and Assessment [NCCA] (2013): Background Paper and Brief for the Review of Junior Cycle Science, 2013, S. 1–52.

National Research Council [NRC] (1996): National Science Education Standards. Washington, DC: National Academy Press.

Oreskes, Naomi (2004): The Scientific Consensus on Climate Change. In: *Science* 306 (5702), S. 1686. DOI: 10.1126/science.1103618.

Pawek, C. (2009): Schülerlabore als interessefördernde außerschulische Lernumgebungen für Schülerinnen und Schüler aus der Mittel- und Oberstufe, Kiel.

Streller, S.; Bolte, C. (2008): Tornados im globalen Klimageschehen. In: *PRAXIS DER NATURWISSENSCHAFTEN CHEMIE IN DER SCHULE* 57 (2), S. 11.

Yager, Robert E.; Akcay, Hakan (2010): The Advantages of an Inquiry Approach for Science Instruction in Middle Grades. In: *School Science and Mathematics* 110 (1), S. 5–12.

Note: *This Workshop is part of the PhD research by Louise Bindel at the University of Halle, in Germany, supervised by Prof. Dr. Martin Lindner. The PhD is funded by the German Foundation of Business (sdw), which also enabled a six months research stay at the National Centre for Excellence in Mathematics and Science Teaching and Learning, Limerick, where she was supervised by the Director, Professor John O'Donoghue.*

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Chemlingo: Extremophiles

Peter E. Childs

In an earlier Chemlingo (1) we explored the meaning of the suffices – **-phile** (lover), **-phobe** (hater) and **–phore**(carrier) in chemistry. A new angle on these terms is their widespread use by biologists to describe new types of bacteria being discovered in extreme environments and referred to collectively as extremophiles. (2) (A word that could also be used to describe the devotees of extreme sports.) They have even featured in *Time* magazine (3). New ecosystems have been discovered in locations once thought inhospitable to life, colonized by new species of bacteria and *archaea* (ancient organisms.) One example is in the deep oceans near deep sea vents, which spew out hot, toxic fluids, rich in metals and sulphur. Bacteria and other species live in these hot, poisonous locations and love it. They use sulphur, hydrogen and metals in their metabolism, a process called chemoautotrophy (or chemotrophy). They get their energy supply from chemistry without using sunlight in photosynthesis. Autotrophy means being able to live solely on chemical compounds.

Some bacteria that live in high salt concentrations are known as halophiles (salt lovers); some love carbon dioxide and are carbophiles; some love rocks and are lithophiles; some love heat (thermophiles) and others cold (cryophiles, also known as psychrophiles). Those that like it really hot (>80^{o}C) are known as hyperthermophiles. Some love acidic (acidophiles) and others alkaline surroundings (alkaliphiles). Some bacteria like it really dry and can spoil even dry food as they don't need water. They are known as xerophiles, from the Greek *xeros* = dry, hence xerography,or dry writing. Iron-loving bacteria are ferrophiles, but it is also used to describe people who love iron in any shape or form, or who are devotees of Iron Man. Osmophiles are able to survive in high sugar concentrations (high osmotic pressure).

It would seem that bacteria can adapt to any environment and they can use exotic chemicals and effect unusual chemical transformations in their battle to survive. Can you guess what barophiles are? It's not another name for those who love pubs but organisms that love being under pressure! They are also known as piezophiles. Biochemists are eagerly seeking new enzymes from these extremophiles, which will act as catalysts outside the environmental ranges that most enzymes require. This will enable these extreme enzymes to be used in novel biotechnological processes that are not possible today.

References

1. P.E.Childs, (1999) *Education in Chemistry*, 36(6) p.149
2. http://en.wikipedia.org/wiki/Extremophile
3. *Time* 5/8/2002 36-39

Conference Reports

Chemistry is all Around Us: "Initiatives in Chemistry Teacher Training"

Limerick Institute of Technology, Nov. 29th 2013

The international conference "Initiatives in Chemistry Teacher Training" took place in Limerick on 29th November 2013 in Limerick Institute of Technology City Campus at George's Quay. The aim of the conference was to share European experiences and initiatives for pre-service and in-service training of chemistry teachers and then to focus on initiatives to enhance chemistry teacher training from an Irish perspective. The Conference was funded by the 518300-LLP-2011-IT-COMENIUS-CNW Chemistry is All Around Network project resources. It was part of the prescribed activities of the Chemistry is All Around Us Network and follows on from the initial conference on Training Issues of Chemistry Teachers in Gabrovo, Bulgaria in June 2013.

The morning session centred around the European experiences collated through the Chemistry is All Around us Network Project, and the afternoon devoted to various aspects of chemistry teacher training in Ireland, and beyond, since some of the initiatives were instigated as part of European collaborations.

In addition to the conference talks, poster presentations were displayed, giving the participants had the opportunity to examine the posters presented and to discuss their contents with authors during the breaks midway through the morning and afternoon sessions. The full conference programme is available on the conference web site:
(http://www.lit.ie/ICTT/default.aspx).

Some forty participants registered from a number of European countries, with the largest representation from Ireland. These included representatives from universities, schools, educational companies and public authorities. They were welcomed to the George's Quay campus by Michael O'Connell, Limerick Institute of Technology's Vice-President for Strategy, Internationalisation and Marketing. His welcome was echoed by Michelle McKeon-Bennett, Head of Department of Applied Science in Limerick Institute of Technology. The Chairperson for the day was David Sutton, a lecturer in the Department of Applied Science in Limerick Institute of Technology who is also a member of the Irish team of experts for the Chemistry is all Around Us Network Project.

The papers presented addressed Initial Teacher Education and In-service Education, with some of them focusing on the use of information communications technologies to enhance the teaching experience, as well as continuous professional development in the use of inquiry-based strategies. All of the European project partners spoke about issues and initiatives in their own countries, and the morning session concluded with a review of *Initiatives in Chemistry Teacher Training in Ireland* by **Marie Walsh**. This outlined the current status of reform in all education components in Ireland, which, in the case of teacher training, have been informed by the Sahlberg Report (July 2012). This concluded *'in order to advance further in its national teacher education system, Ireland needs to invest more in the continuous improvement of the quality of teaching, the role of research in teacher education, and international cooperation in all of its teacher education institutions'*. The current system of pre-service training was described, with some comparison of concurrent versus consecutive training and the implications of each for subject content knowledge and pedagogical skills training. Continuous professional development to maintain the state of the art in a scientific discipline like Chemistry was recognised as being vital. To this end the talk merged with one by **Peter Jackson**, who described the role of the *Professional Development Service for Teachers* (PDST). He is a practising Chemistry teacher who is also a member of the PDST team for Chemistry. He explained the work of the team and their countrywide interaction at Teachers Centres. They ensure material presented at training sessions is useful, are forward-looking, cross curricular links are stressed, making resources available to all teachers and they address literacy and numeracy issues.

The conference lunch was held in the Hunt Museum, which was a short walk away from the venue for the talks. This gave participants a chance to meet partners from other countries and to discuss the issues in a less formal setting.

When the participants reconvened at George's Quay they heard an overview of the *Chemistry Is All Around Network Project: The Transnational Report* by M.M.Carnasciali and L.Ricco and presented by **Marilena Carnasciali**, the project leader from University of Genoa. Her report showed how the project network is expanding internationally. She has concluded that the project is making a valuable contribution to the training of teachers because it allows the experts to deal with the international reality. It also increases their knowledge in the field of training and to discuss with teachers of all levels, establishing a solid contact with schools, their problems and needs. It also has allowed the teachers involved to have people to contact for improving their teaching methodology and for all users of the portal to update about teaching chemistry in Europe and find ideas for new teaching methodologies.

The afternoon sessions then shifted focus to Irish initiatives. Talks were given by representatives of Chemistry and Science Education Research Groups in a number of Irish third level institutions with involvement in either or both pre-service and in-service training of teachers. Many of the presenters are members or associates of the Chemistry is All Around Us Network in Ireland. The first of these talks was from **Peter Childs**, one of the pre-eminent chemistry education researchers in Ireland. His talk *From SER to STL: translating science education research into science teaching and learning*, encouraged the implementation of research findings into teaching and learning.

The theme of 'Misconceptions' was a major component of *Pre-service Primary Teachers Ideas in Chemistry* by **Maeve Liston**. She shared her on-going research findings regarding the scientific knowledge of pre-service primary school teachers and also described proposed future work to redress the misconceptions issue: to design and implement the Conceptual Understanding Chemistry Course where the pre-service teachers will be confronted with 'chemical events' that evoke conflicts between everyday conceptions and chemical theory.

The theme continued with a description of on-going research with pre-service secondary school teachers at the University of Limerick in *Investigating and Addressing Chemistry Misconceptions in the Subject Matter Knowledge and Pedagogical Content Knowledge of Pre-service Science Teachers* which was outlined by **Muireann Sheehan** and co-authored by Peter Childs. Their research has shown that the level of misconceptions is high, and worryingly, that it does not decrease over the lifetime of the undergraduate training programme. Phase 2 of the research includes design of a blended-learning intervention, including a website subatomic. The intention is that this website is a place where the Pre-service science teachers can: revise their own understanding of lower second-level (Junior Certificate) chemistry topics, learn about common pupil misconceptions which they may come across in the classroom, get diagnostic questions, resources, ideas for teaching activities and information about the Junior Certificate science syllabus, learn about research ideas and strategies relevant to developing conceptual understanding and targeting misconceptions among their pupils, and to get advice from experienced teachers/researchers about teaching chemistry (in the form of short articles).

The next two talks shifted emphasis to the use of ICTs in chemistry teaching. **Claire McDonnell** from Dublin Institute of Technology addressed the topic *Applying Technology to Enhance Chemistry Education.* Claire described her experience as a guest editor for the Royal Society of Chemistry special themed issue of the journal *Chemistry Education Research and Practice*, before going on to talk about her own experiences of using Wikis and Peerwise. One telling quote has resonance for all: ***"Technology will not replace teachers, but teachers who use technology will replace the teachers who do not,"*** Clifford, R. (Defense Language Institute) quoted in Moeller, A. J. CALICO Journal, 1997, 14 (2-4), 5-13.

Mark Glynn from Dublin City University spoke on *Using Moodle for sustainable professional development for teachers.* This talk gave an overview of the potential for Moodle, both for in-house back-up for lessons and also for distance training initiatives.

After a short break to allow discussion and viewing of posters, the final talks of the day commenced. The first of these *The use of Visual Aids for concrete learners: Facilitating understanding in Organic Chemistry* was presented by **Anne O'Dwyer** (in conjunction with her supervisor Peter Childs), who demonstrated her research findings supporting the use of models to facilitate understanding of structures and reactions of organic molecules. She spoke about the multi-dimensional nature of Chemistry, cognitive development and its impact on the learning and understanding of abstract ideas – and particularly the cognitive demand of Organic Chemistry. The talk concluded with illustrations of the potential for using concrete models to teach abstract concepts.

Sarah Brady, from the CASTEL Centre for Advancement of Science Teaching and Learning in Dublin spoke about *Developing and Implementing Teacher Education Programmes & Resources for teaching Chemistry*. She shared experiences of developing and implementing teacher education programmes and resources for teaching chemistry. This work has been made possible through CASTEL's involvement in two particular projects. The first is the ESTABLISH project, which is an FP7 Science in Society coordination and support project which they coordinate and the second is the Amgen Science Teacher Training Initiative, which has been run as a pilot project for the last two years. Two positive results from these initiatives have been: observed changes in the profile of teachers' understanding of Inquiry-based science education (IBSE) and very significantly, buy-in from Ministries of Education to roll out national programmes of continued teacher professional development.

The final talk of the afternoon was on *Technology Enhanced Learning in the Chemistry Classroom* by **Michael Seery** who was guest co-editor of the special themed issue of *Chemistry Education Research and Practice* mentioned earlier. He described on-going research and practice in the implementation of ideas to reduce cognitive overload for students, ideas like the use of worked examples, wikis, jump-starting lectures, podcasting and screen-casting. This gave a myriad of ideas for in-service actions that might motivate students in their studies of chemistry, and also ensure that teachers are responding to the appropriate use of technologies.

Marie Walsh (conference organiser)

The Proceedings of this conference are available: **http://www.lit.ie/ICTT/Papers/Papers/Chemistry%20is%20all%20around%20us%20Conference%20on%20Teacher%20Training%20Limerick%20November%2029th%202013.pdf**

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ISTA Conference: *Inspiring Science from Ireland's Silicon Valley*

April 11-13th 2014, NUI Galway

The 52nd Annual Conference of the Irish Science Teachers' Association (ISTA) was held in NUI Galway on 11th to 13th April 2014. There was a good attendance the conference. The organising committee deserve credit for preparing a well-run and interesting programme.

Commissioner Maire Geoghegan-Quinn officially opened the conference on Friday evening. She acknowledged the European research budget that has been dedicated to Science education and public engagement. She mentioned the many projects that have helped to develop inquiry-based methods to improve pupil engagement in Science. This was followed by the introductory lecture by Prof. Elaine *Fox on 'Rainy Brain, Sunny Brain: From Pessimist to Optimist; can we really change?'* This was an excellent and engaging talk, showing the audience how we can use techniques to overcome pessimism and become more optimistic.

The programme on Saturday offered a choice of workshops, talks and exhibitions. The PDST offered interesting, practical and hands-on Biology, Chemistry and Physics workshops. Prof. Donal O' Shea delivered a very thought-provoking talk '*Science Teachers and Discovery in Obesity*'. In a a review of the research he has carried out, he highlighted the alarming increase in obesity and the risks and complications that this epidemic presents. Over lunchtime, there were a series of drop-in workshops about the different European-funded science education projects.

After lunch Prof. Martyn Poliakoff charmed the audience as he told the story of how his Periodic Table YouTube videos have been developed and viewed by over 52 million since he began the recordings less than 6 years ago.

All participants were very interested in Prof Aine Hyland's summary of her recent report *'The design of Leaving Certificate science syllabi in Ireland: an international comparison'*. Her talk on Saturday afternoon clearly detailed how the changes in senior science syllabi in Ireland compare with best practices in curriculum, syllabus and assessment design internationally.

Prof. Jim Al Khalili concluded the conference on Saturday afternoon with his talk *'Is life Quantum Mechanical?'* where he outlined the role of quantum mechanics in Biology.

Anne O'Dwyer

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9th Irish Variety in Chemistry Education
Dublin Institute of Technology, May 6th 2014

The **9th Irish Variety in Chemistry Education meeting** was held in Dublin Institute of Technology on May 6th 2014. Fourteen talks were crammed into the day and a brief summary of the main themes are below, along with some useful links and references to follow up.

Peter Childs opened the meeting with a perspective on the state of teaching and learning chemistry in Ireland.[1] In this he outlined several issues facing chemistry teachers at third level, which will resonate with many outside Ireland. These included the difficulties around the language of chemistry,[2] the prevalence of misconceptions,[3] and the lack of engagement of third level lecturers with chemistry education research.[4] On a similar note, **Maria Sheehan** gave the first keynote, and her talk included information on the chemistry syllabus at school level, and what we could expect at third level from students who had and had not completed chemistry before.[5] It was interesting to note that chemistry at school does not capitalise on using contexts, in a manner which biology and physics taught at the same level appear to have. Students with different levels and abilities featured in **John Keary**'s talk—his work showed that students receiving lower assessment marks tended to over-estimate their grade, whereas those receiving higher marks tended to under-estimate the actual grade.

How can we address teaching and learning issues in chemistry? Luckily, the meeting provided several examples and ideas. *Laboratory education* was one of the three themes discussed. **Anne O'Dwyer** discussed the implementation of inquiry-based labs in undergraduate chemistry. Her exploratory study investigated what undergraduates, postgraduate demonstrators, and academic staff thought about the inclusion of IBL in the laboratory. Students reported that while the labs required more work, they were more interesting and required deeper thinking. Demonstrators, 4 out of 5 of whom had no experience in inquiry based teaching and learning, thought that the method would have a positive effect on their own research skills. Lecturers agreed that the approach had positive outcomes, but cited some barriers such as cost and time. Recommendations for proceeding with including the approach in the curriculum were outlined. **Teri Donaghy** described the use of a systematic online personalised feedback grid for advanced laboratory practicals which used rubrics and audio feedback for students. The rubrics ensured some consistency among different assessors was maintained. **Mike Bridge** spoke about the development of an online workshop for large numbers of first and second year students, whereby students would complete the induction to safety in advance of the laboratory work.

Transferable skills were the second theme of the meeting. **Julie Dunne** spoke of a community engagement project, where chemistry students assisted in the analysis of soap made by a local artisan manufacturer to identify why some soap spoiled.[6] Including the method in the curriculum meant that students were applying their specialist subject skills on real projects and receiving course credits for the work. **Samantha Pugh** discussed the "*Chemistry: Idea to Market*" developed with funding from the RSC[7] and "*Chemistry: Making a Difference*" developed with funding from the Higher Education Academy. These involved the integration of some commercial awareness into the curriculum and again, related the students' specialist knowledge with expertise drawn from innovators and industrialists involved in the project. **Trini Verlasco-Torrijos** spoke about her implementation another RSC-funded resource "*Molecules against Malaria*"[8] which they used as part of a suite of student learning activities in communicating and applying chemistry to context-based scenarios.

Finally, *technology* was the third theme of the day. Interestingly, these all had a peer-element to them. **Christine O'Connor** spoke about her development of a PeerWise community with a group of first year chemists[9] and found that students submitted and answered more questions than required. **Barry Ryan** spoke about his integration of PeerWise with in-class clicker work and assessment by MCQs. Student-generated PeerWise questions were used in class and students had a second chance to discuss answers in groups.[10] **Eileen O'Leary** demonstrated the use of Socrative App that eliminated the need for physical clickers in the classroom.[11] And **Suzanne Fergus** answered several questions from the sceptics in the room (myself included) by exploring the student comments on the PeerWise questions submitted by their peers. She demonstrated that students were quite good at spotting where questions could be improved, or where they were too easy for revision. She recommended that a workshop be given to students on how to write suitable questions as part of the induction to PeerWise (see also ref. 9). **Simon Lancaster** finished off the day with a discussion on the use of technology in chemistry education, including getting students to prepare a screencast of a particular topic ("vignette") that can be used as a class revision tool;[12] the use of screencasts to give students effective feedback on their presentations; and on the use of Twitter for professional development. There was a shout-out for the **Chemistry Education Links Scoop** (thanks Simon!) and a promise to Storify the entire meeting's tweets, which had the hashtag: #ivice14. True to his word, you can read Simon's Storify at the address: https://storify.com/S_J_Lancaster/irish-variety-in-chemical-education-2014

Exhausted, but well-informed, the audience left looking forward to the UK Variety meeting, which is being held in Durham in August.

My thanks go to the meeting sponsors (National Forum for Enhancement of Teaching and Learning and the Royal Society of Chemistry) as well as Dr Bill Byers for his enthusiastic support of the Irish Variety since the beginning. Next time we will celebrate the 10th meeting.

Notes and references

1. For a fuller exploration of this topic, see the recently published article: Childs (2014) The state of chemical education in Ireland, *Irish Chemical News*, 1, 16-25. Available online at **http://www.chemistryireland.org/html/ichemnews.html**.
2. Peter used the example of the "*Montillation of Traxoline*" to illustrate how novice learners might view a new chemistry topic – see **https://twitter.com/S_J_Lancaster/status/463636392783147008**.
3. See: Sheehan and Childs (2011) Pre-Service Irish Science Teachers' Misconceptions of Chemistry,*ESERA Conference Proceedings*, available at: **http://www.esera.org/publications/esera-conference-proceedings/science-learning-and-citizenship/strand-12/**.
4. For a discussion on this topic, see the recent *EiC* blog article: http://www.rsc.org/blogs/eic/2014/02/impact-innovations-teaching
5. Childs and Sheehan (2009) What's difficult about chemistry? An Irish perspective, *Chemistry Education Research and Practice*, 10, 204. [http://pubs.rsc.org/en/content/articlelanding/2009/rp/b914499b].
6. See the *Students Learning with Communities* project page at **this link**.
7. See Learn Chemistry: **http://www.rsc.org/learn-chemistry/resource/res00000948/chemistry-idea-to-market** For a related resource: "*Commercial Skills for Chemists*", see **http://www.rsc.org/learn-chemistry/resource/res00000953/commercial-skills-for-chemists-introduction-and-overview**.

8. See Learn Chemistry: **http://www.rsc.org/learn-chemistry/resource/res00000933/molecules-against-malaria**.
9. For more on PeerWise, see the 2013 *EiC* article *Student Generated Assessment*:**http://www.rsc.org/education/eic/issues/2013January/student-generated-assessment.asp**.
10. See Ryan (2013) Line up, line up: using technology to align and enhance peer learning and assessment in a student centred foundation organic chemistry module, *Chemistry Education Research and Practice*, 14, 229-238 [http://pubs.rsc.org/en/Content/ArticleLanding/2013/RP/C3RP20178C]
11. See **www.socrative.com**
12. For more on this topic, see the recent *EiC* article: *Beyond the Presentation: student authored vignettes:***http://www.rsc.org/eic/2014/03/student-vignette-presentation**. Some videos on how to prepare and edit vignettes are available here: **http://www.chemistryvignettes.net/editing-vignettes/**.

Michael Seery (conference organiser)

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12th ECRICE, "New Trends in Research-based Chemistry Education"

July 7-10th , 2014 University of Jyväskylä, Jyväskylä, Finland

Often the school classroom / lab, in which you find yourself, is constrained by certain things such as the architecture of the room, the (lack of) resources, the time afforded to teach versus the scale of the curriculum. Getting the opportunity to attend an event such as 'The European Conference on Research in Chemistry Education' brought it home to me that others are facing the same issues - from Russia to South America and from Europe and Israel to Australia. There were other common denominators.

The heartening thing about getting the chance to hear about the research of others was seeing the commitment that underscores the work that chemistry educators have in relation to their students learning and the ideas they had to try, in order to overcome the obstacles that they were routinely facing.

It was inspiring to hear the passion people had for their subject and see the will they had to help their students - in a primary school, secondary school, third-level, teacher training setting and on outreach programmes. Glimpsing some of the resources that might be used in chemistry teaching in the future in both pedagogical and assessment terms was entertaining and thought-provoking. Technology appears to have an increasingly important role and potential in assisting teachers in this regard. Also, with advances in the technological field, it seems there will be more freely available software to allow educators creatively address teaching and learning issues in a way that can be adapted so as to best suit their own specific students.

The idea I had coming away from the event was that there is no 'silver bullet' when it comes to teaching and learning with the group of students that sit in front of you in any given year. These are unique groups, with different individual and collective needs and this provides us with part of the challenge we try to meet as teachers. Reassuringly, however, there is an active global community in chemistry education who are willing to share ideas and collaborate with one another for the greater good of their students. Attending an international science education conference such as the one in Jyväskla, Finland made me more aware of such a sustained network of support. Aside from participants from an array of countries, there were also participants from Ireland (from the University of Limerick and Dublin City University), who gave very interesting and well-received presentations. These people also participate in ChemEd-Ireland conferences and the Irish Science Teachers Association conferences, which helps to ensure that advice given at such events is in line with best practice internationally.

I would recommend attending such a conference to anyone who is teaching chemistry but if time does not allow you to travel, it is worth remembering our that own national subject conferences in the sciences also serve to provide you with very good ideas and support.

Enda Carr

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Information Page

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