



Chemistry

In Action!

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40th Birthday Issue

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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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Editorial #115

40th birthday issue

Chemistry in Action! was launched as a Newsletter in May 1980 at the Institute of Chemistry of Ireland's annual congress in Sligo. Over the years it has increased in size and style and for many years has been a magazine. Spring 2020 marks the 40th birthday of *Chemistry in Action!* Its overall aim has been to improve the teaching of chemistry in Irish schools by equipping the teachers with information and ideas. You, the readers, are best able to judge whether it has achieved its aim and since it started a generation of chemistry teachers has been and gone.

To mark this anniversary, I asked several people to write retrospective articles on the changes that have happened in the last 40 years in various areas related to chemistry and chemical education, science and science education. I would like to thank all the contributors who made it in time for this issue and I hope you, the readers, find these articles of interest. For some of you it is ancient history and for others it is their history. I ended up with too much for one issue and so several articles have been carried over to the next issue.

The Ireland of 2020 is different in many ways to the Ireland of 1980, not least in the area of education in general, and in science education in particular. The Regional Technical Colleges (RTCs) have morphed into Institutes of Technology (IoTs) and now into Technological Universities. The number and percentage of children staying on to the end of year 6 of second level education has increased dramatically, as has the percentage going on to various third level courses.

The chemical industry, now known as the biopharmaceutical industry, has grown enormously, as have the other high-tech sectors of the economy. The chemical industry helped keep Ireland afloat during the recession and will play a major part in helping the country weather the Covid-19 pandemic. We can be proud of Ireland's biopharmaceutical industry and the men and women who work in it, most of whom came up through the Irish education system.

The Young Scientists Exhibition (YSE) goes from strength to strength, and is one of the world's

premier science fairs, but it has been joined by the SciFest and Mini Scientist competitions, not to mention the successful annual National Science Week (since 1996). Science outreach has grown in many ways over the years, especially since 2000.

Science research has grown enormously since 2000, with the support of SFI and other government initiatives, and Ireland has become a significant player on the world stage in science research. There has also been growth in science education research (SER). Science education and maths education have now become STEM education, including Technology and Engineering education, and successful STEM research centres have sprung up in several third level institutions, like CASTel and Epi*Stem. Ireland has become a valued member of the EU research community and has been involved in many EU funded STEM projects.

Second level science has seen several changes in the curriculum at LC level and in the junior cycle, and Primary Science has become part of the primary curriculum. There is ongoing, if controversial change, in the junior cycle and soon in the senior cycle.

Thanks

There are too many people to thank individually over the past 40 years – our industrial sponsors whose financial support have made it all possible; Marie Walsh for her invaluable help since 1988; Thomond College and then the University of Limerick for providing their facilities, and especially the staff of the print room; also many, many authors over the years; my assistant editors; and above all my supportive readership among the chemistry teachers of Ireland.

Chemistry in Action! has changed from a totally printed version to a mix of electronic and print, due to increased postage costs. It is now available sooner online and it reaches a large audience (I hope), than the printed version did. More birthday articles will appear in issue 116.

Peter E. Childs

**Hon. Editor
1980-2020**

In this issue: 40th birthday issue!



The main bulk of this issue consists of commissioned retrospective articles on various aspects of Irish life relating to science/chemistry and science education, from 1980 to 2020. This turned into more material than expected and so this birthday tribute is being presented over two issues – this one and #116, Autumn 2020.

This section starts with an overview of developments in science education and science education research by Peter Childs, to set the scene for what follows.

The development of chemistry/science education from primary to university level is then covered in a series of articles. Primary science is surveyed by Anne O'Dwyer and Miriam Hamilton.

The development of the chemistry curriculum in the Republic of Ireland over 100 years is described by Randal Henly. This is followed by a survey of science curriculum developments in N. Ireland by Roger McCune. Up until 1921 they would have had a common educational system, but since partition they have diverged and N. Ireland is more closely aligned with England and Wales, although it has its own unique features.

Marie Walsh then writes about the development of the Regional Technical Colleges, now Institutes of Technology (IoTs), and soon to become Technological Universities.

The hope is that teachers will find this series of articles interesting, even if a generation of chemistry teachers has come and gone since *Chemistry in Action!* started. This overview will be continued in the next issue.

In the next issue we will have an article on Chemistry in the Universities since 1980 by Peter Childs, to complement that on the IoTs.

Martin McHugh and Sarah Hayes will look at the development of science outreach and engagement.

Odilla Finlayson will survey the history of Ireland's involvement in the International Chemistry Olympiad.

We are also hoping to have an article by Matt Moran on the development of the chemical industry in Ireland since 1980. This is an important topic as the industry has been a mainstay of Ireland's economy and has provided jobs for many Chemistry graduates and postgraduates. Support from the industry has also made publication of *Chemistry in Action!* possible for 40 years.

Some other general articles had to be held over from this issue and will appear in issue #116.

Wanted:

If you have any reminiscences or comments on how *Chemistry in Action!* has helped your teaching, please send them in by September 1st to the Editor for the next issue in the Autumn (peter.childs@ul.ie).

Limerick competition

To mark the 40th birthday of *Chemistry in Action!*, why not try your hand at a chemical or scientific limerick? The best entries will be published and the top 5 will get a copy of Peter Davern's book of Periodic Table limericks. The limericks must be original. Send them by September 1st to peter.childs@ul.ie.

Education News and Views

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

The cost of Covid-19

I am writing this at the end of April 2020, several weeks into the lockdown and cocooned in my house. This is the year that never was and the effects of the virus, on human lives and on the economy, will live with us for years. Education has been disrupted, especially for those due to sit the Leaving Certificate this summer, with its implications for progress to third level, and also final year students in universities and IoTs who expected to graduate and move onto into their careers. All these things are now uncertain and many jobs are at risk and many careers will be disrupted. Teachers at second level and third level have had a crash course in how to teach (and assess) online and it may be that science education will never be the same again. The loss of overseas students will have a major financial impact on Irish third level institutions.

One of the casualties of the pandemic has been the year's programme of science/chemistry education conferences. Luckily the ISTA got in early this year with their own conference from 7-8th February; if it had been held at its usual time at the end of March/early April then it would have been cancelled.

The 2020 Biennial Conference on Chemical Education scheduled for July 18-23, 2020, at Oregon State University in Corvallis, OR, USA has been cancelled. The next BCCE will be in 2022 in Purdue.

The Symposium on Chemical Education at the University of Ludwigsburg in late May has been postponed to September.

ECRICE 2020 was due to be held in early July in Israel and has been moved to 2022. ICCE was scheduled for South Africa in July and has been moved to 26-30 January 2021.

<https://iupac.org/event/chemistry-education-icce-2020/>

The biannual SMEC Conference hosted by CASTeL at DCU was due to be held this summer. It has been postponed to 2021. The BASF Summer School in UCC and the Chemistry Demonstration Workshop in UL have both been cancelled for this year. However, Declan Kennedy is going ahead with planning for ChemEd-Ireland

2020 in UCC on Saturday October 17th. Let us hope that the restrictions on meeting are lifted by then. Some meetings are being held by video conferencing and this works quite well but its not the same as face to face meetings and the social dimension is missing. (See the Diary on p. 65).

ChemEd-Ireland 2020

This year's ChemEd-Ireland conference is still scheduled for Saturday October 17th at UCC. Dr Declan Kennedy is chair of the organising committee. In recent years the UCC conferences have been the best attended ChemEd-Ireland conferences and it is hoped that it will be able to go ahead. Watch out for information or register your interest with Declan at d.kennedy@ucc.ie. If it doesn't happen because of the Covid-19 restrictions, then it will be postponed to the following year. The future ChemEd-Ireland schedule is as follows (subject to revision):

2021	DCU (the 40 th)
2022	LIT
2023	TCD
2024	UCC
2025	TUD
2026	UL
2027	DCU

Chemistry Development Group, NCCA

New specifications for LC Physics, Chemistry and Biology are scheduled to be introduced in 2021.

The final curriculum specification for each subject will be published a year earlier in September 2020, and the committees started work in September 2019.

Pressure had mounted from 2006 for more frequent revision of syllabi and new LC science curricula and new draft specifications (as they were called) for Biology, Chemistry and Physics were published in 2011, and interested parties were requested to send in comments by the end of 2011. A report on the Consultation was published in 2012 and will be considered by the Chemistry development group.

https://www.ncca.ie/media/2559/science_consultation_report.pdf

The membership of the chemistry development group is given below.

Chair John O'Reilly (UL)
Association of Community & Comprehensive
Schools Brenda Kelly
Association of Secondary Teachers, Ireland
 Pauline Nagle
Association of Secondary Teachers, Ireland
 Mary Mullaghy
Co-opted Odilla Finlayson (DCU)
Co-opted James Lovatt (DCU)
Department of Education and Skills
 Declan Cahalane
Education & Training Boards Ireland
 Móirín Nic Fhlannchadha
Irish Business and Employer's Confederation
 Siobhán Dean
Irish Science Teachers' Association
 Lisa Darley
Irish Universities Association
 Declan Kennedy (UCC)
Joint Managerial Body
 John Mulvihill
National Parents Council Post Primary
 Robert Clarke
State Examinations Commission
 Fiona Desmond
Teachers' Union of Ireland
 Robert Morris
Teachers' Union of Ireland
 Christopher Hegarty

Women in STEM Subjects

The percentage of women studying STEM subjects at school and at third level, and taking up careers in STEM subjects, continues to be a major international concern. The problem is worst in the

physical sciences, engineering and IT. Two recent studies are described below.

Missing Elements

A new report from Teach First, *Missing Elements – why 'steminism' matters in the classroom and beyond*, a UK body which recruits graduates into teachers, has coined a new word – 'Steminism'. The report looks at the issue of attracting women into STEM subjects.

STEMinist noun /'STEM.i.nɪst/

A person who fights for a world where women have equal access to science, technology, engineering and maths roles that are too often dominated by men.

https://www.teachfirst.org.uk/sites/default/files/2020-02/teach_first_steminism_report.pdf

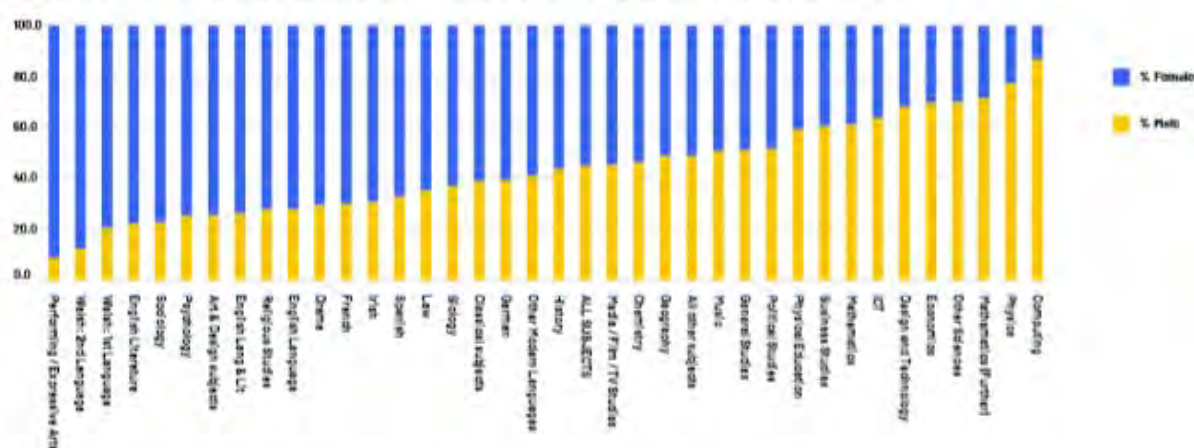
"Science, Technology, Engineering and Maths (STEM) subjects have always been top of the list of teacher shortages. We know schools in challenging circumstances are finding it especially difficult to recruit the quality teachers needed to inspire the next generation of scientists, engineers and mathematicians.

This paper focuses on the gaps that are particularly prevalent in science education, where women are underrepresented and where enormous effects are seen spilling into the STEM labour market. Overcoming these gaps will help us remove gender bias more widely, and allow every child and young person to develop their own talents and interests.

For this project we consulted the evidence on female underrepresentation in the STEM sector, investigated science curricula and surveyed the public. We also spoke in depth to eight female Teach First-trained STEM teachers, asking them what the barriers are to engaging more girls in their subjects, and what they think would help overcome them."

Figure 1 in the report shows the underrepresentation of girls in A-Level subjects (RHS).

Figure 1: Differences between male and female A-Level subject choices – summer 2019



Source: Joint Council for Qualifications, A-level Entry: Gender, A*/A – A* & Regional Charts, 2019

The report makes 3 recommendations to help solve the problem of underrepresentation of girls/women in STEM courses and careers at school and beyond.

1. Reward schools that successfully tackle gender stereotypes and increase the proportion of girls pursuing STEM subjects.
2. Teach STEM subjects in ways that champion female STEM trailblazers and showcase the diverse range of people who have made major contributions to science. The teachers we spoke to for this paper reported that the way STEM subjects are taught – particularly what and who is emphasised in the curriculum – makes a significant difference.
3. Make sure that every school in the country has high-quality, well-supported STEM teachers. To overcome the shortage of STEM teachers, there needs to be more financial incentives for STEM teachers working in schools in disadvantaged communities. This will help get great teachers to where they're needed most. If we don't solve the challenge of teacher shortages, we face a circular problem of generations of young people not gaining the opportunities they need.

In the long-term, gender stereotypes must be challenged across all subject areas. This means helping both boys and girls to pursue their talents

and interests, without being held back by pre-conceived ideas of the roles they should or should not fit into

The message isn't new and other surveys have pointed out the importance of role models for girls – in the classroom, in textbooks, in the media, as a key factor in promoting STEM courses and thus STEM careers.

See for example the report from Microsoft on Closing the STEM gap.

<https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RE1UMWz>

Gender Gap in Science Report



The (preliminary version of the) Gender Gap in Science Book is now on line

https://gendergapinscience.files.wordpress.com/2020/02/final_report_20200204.pdf

This book reports on a three-year project (2017–2019) funded by the International Science

Council and involving eleven scientific partner organizations. The main goal of the project was to investigate the gender gap in STEM disciplines from different angles, globally and across disciplines. We have performed (i) a global survey of scientists with more than 32,000 responses; (ii) an investigation of the effect of gender in millions of scientific publications; and (iii) the compilation of best practices to encourage girls and young women to enter STEM fields, available as a website.

They conclude that the gender gap is very real in science and mathematics. They present methodologies, insights, and tools that have been developed throughout the project, as well as a set of recommendations for different audiences: instructors and parents; educational institutions; scientific unions and other organizations responsible for science policy.

The main survey had 32,346 respondents from 159 countries, half male and half female.

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Grant to MIC & Clare Education Centre to Enhance STEAM

The Department of STEM Education at Mary Immaculate College (MIC), in partnership with Clare Education Centre, has been awarded a €360,000 grant from Erasmus+ to fund research in STEAM Education. The funding provided will be used for the development of STEAM (Science, Technology, Engineering, Arts, Mathematics) expertise in primary schools in Ireland and throughout Europe.

Led by Clare Education Centre, this 3-year research project aims to ensure that all learners have access to high quality STEAM/STEM education. The Department of STEM Education at MIC and Clare Education Centre will partner with organisations in four different countries and through the development of specialist STEM teachers, known as ‘STEM Champions’, children in schools in Ireland, Portugal, Croatia, Norway, and Greece will be given the opportunity to proactively engage in STEM learning.

Head of the Department of STEM Education at MIC, Dr Aisling Leavy, said: “A key priority in European and national policies is to increase knowledge and competence in STEAM subjects, thereby fostering essential innovation and creativity. We are delighted to contribute to this effort through identification and analysis of best practices in STEAM education at primary and

secondary school levels. This Erasmus+ award, targeted at developing strategic partnerships for school education, focuses on engaging students in the creation of their own STEAM learning.”

She continued by saying, “This grant is an opportunity for the Department of STEM Education at MIC to contribute towards improving STEM literacy in schools and ensuring that all learners have access to high quality STEM education. This research will advance the goals of the Department of STEM Education to bring all learners, particularly those from diverse and marginalised communities, into contact with STEM.”

Commenting on the partnership with MIC, Ray McNerney, Director of Clare Education Centre said: “The promotion of STEAM education and active learning methodologies are core priorities for Clare Education Centre. This project, in collaboration with MIC, will significantly facilitate the development of STEAM education and will result in the development of training programmes, teaching resources and learning activities, which will be of relevance locally, nationally and internationally. In recent years, Michael Browne has pioneered the engagement of many Clare schools in STEAM education and this project will provide opportunities for teachers and pupils to further embrace STEAM teaching and learning”.

He added, “The ultimate beneficiaries of the project are the children whose educational attainment is likely to be enhanced by active involvement in their own STEAM learning”

Cratloe NS, O’Callaghan’s Mills NS and St Senan’s NS Kilrush will be involved centrally in the project in addition to a further twelve schools in Clare. Michael Browne will lead the project for Clare Education Centre with the support of Ray McNerney. The research team from the Department of STEM Education at MIC includes Dr Aisling Leavy, Dr Anne O’Dwyer, Dr Edward Corry and Dr Mairéad Hourigan.

The four partner organisations that MIC and Clare Education Centre will work with over the three years are: Agrupamento de Escolas Carlos Gargate (Portugal), Osnovna Skola Matije Gupca (Croatia), Luster Commune (Norway) and Directorate of Primary Education of Western Thessaloniki (Greece).

<https://www.mic.ul.ie/news/2019/mic-to-enhance-steam-learning-in-schools>

□

2018 PISA Results published

The Minister for Education and Skills Joe McHugh TD today (Tuesday 3 December 2019) welcomed the 2018 OECD PISA (Programme for International Student Assessment) results, which show Ireland's 15 year-olds are among the best in reading literacy and are performing significantly higher than the OECD average in mathematics and science.

PISA takes place every three years and aims to measure how well 15 year-old students are performing in three areas – reading, mathematics and science.

The key findings of the 2018 assessments include:

- Ireland ranks 4th out of 36 OECD countries and 3rd out of 27 EU countries for reading literacy.
- Ireland ranks 8th out of 77 countries/regions involved in PISA 2018 for reading literacy.
- In reading, Ireland has significantly fewer low-performing students (11.8% below level 2) and significantly more high performers (12.1% at levels 5 & 6) than the OECD average.
- PISA results show the difference in performance between schools in Ireland is lower than the OECD average.
- In Ireland, the difference between schools in student performance in reading literacy is less than half of what it is, on average, across OECD countries.
- Post-primary schools in Ireland can therefore be considered relatively equitable, as well as having above average performance in the three assessment domains.

Minister McHugh said: *“Our focus on creating an equitable education system is working. It is particularly heartening to see how the variation between schools is significantly lower than other countries in these PISA results.*

“A large part of that success is down to the focus of Government on the Deis programme.

Irish students have extremely high standards when it comes to reading, among the best there is. The number of low achieving students is among the lowest in the 77 countries tested.

It is an envious position to be in and credit must go to the education initiatives being promoted by the Department like the [National Strategy on Literacy and Numeracy for Learning and Life](#)

(2011-2020) and how these are adopted by our schools, thanks to the dedication of our teachers.

Overall in maths and science results are relatively stable and our students are performing at an above average level, yet we can improve further. I am confident that the changes which the Junior Cycle is bringing will help the development of our students' critical thinking. It is no longer just about the facts and knowledge that we teach our young people but helping them see how they can put that into use.

The Government is committed to promoting the uptake of STEM in post-primary and a key focus is increasing participation of young women. We will be taking account of the PISA results in considering actions in the next STEM Implementation Plan from 2020.

And as part of our work to provide more technology in schools, since 2017, the Government has invested €110 million in ICT in the classroom. That will continue with another €100 million under the Project Ireland 2040 Digital Strategy in Schools and it will ensure students will become more and more adept at using technologies for education.”

PISA 2018 is a computer-based testing format. About half of the 5,000 plus Irish students who sat the tests had previous experience in this type of testing.

Computer-based testing was first introduced in PISA 2015. This allowed PISA to test students' ability to apply scientific investigative skills in virtual experiments. In 2018, the proportion of such items was increased, reflecting a growing emphasis on measuring students' ability to apply scientific skills, rather than their knowledge of scientific facts.

Only 2% of the Irish students taking the PISA 2018 test had experienced the new science curriculum. The 2021 round of PISA will provide a better estimation of the extent to which the Junior Cycle changes in science are effective.

Other findings from PISA 2018

- Ireland has a lower percentage of low-performing students in all three domains than on average across OECD countries.
- Girls perform better than boys in reading, with a difference of 23.2 score points.[\[3\]](#)

- Ireland's performance in science and mathematics has remained relatively stable – above the OECD average scores – between 2015 and 2018 cycles.
- Girls perform slightly better than boys in science but the results are not considered statistically significant.
- In science, students ranked 17th out of 37 OECD countries, 11th out of 28 EU countries and 22nd out of 78 participating countries/regions.
- Ireland has a lower than average number of low performing students in science.
- In mathematics, Irish students ranked 16th out of 37 OECD countries and 21st out of 78 participating countries/regions.
- Ireland has a lower than average number of low performing students in maths.

Further information:

The national report on PISA 2018 in Ireland can be accessed at www.erc.ie.

International reports on PISA 2018 can be accessed at www.oecd.org/pisa.

Sample items from PISA reading literacy, science and mathematics can be viewed in the national report for Ireland. They can be taken interactively at www.oecd.org/pisa

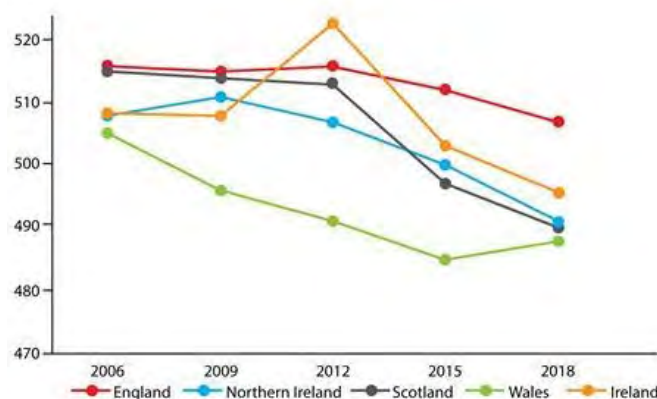
<https://www.education.ie/en/Press-Events/Press-Releases/2019-press-releases/PR19-12-03.html>

Comparison of PISA science scores 2006-2018

It is instructive to compare Ireland's science performance with that of the UK (see diagram below).

Given the different educational systems (see Roger McCune's article in this issue), the Republic of Ireland compares favourably with the four U.K. provinces.

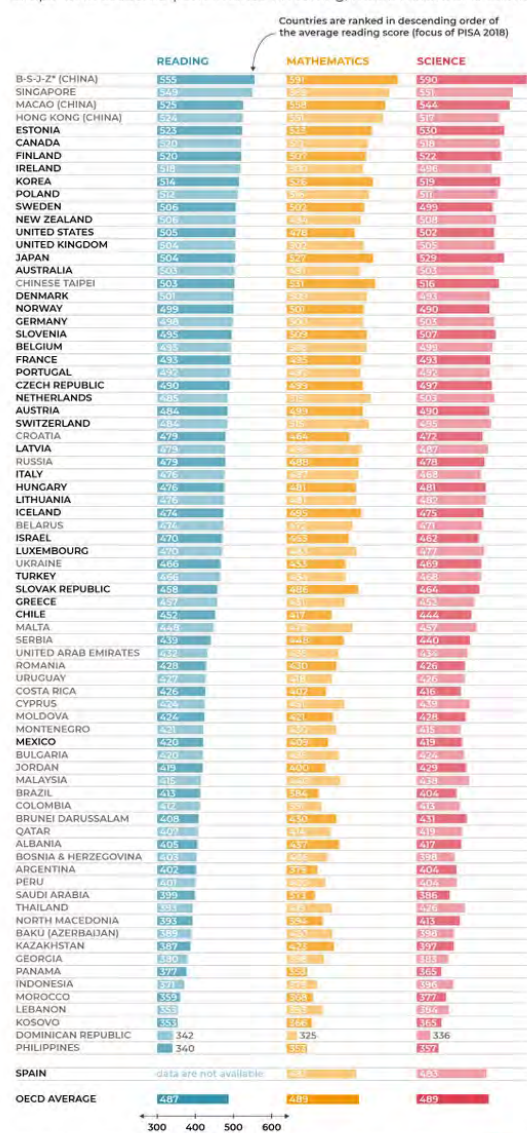
It will be interesting to see in 3 year's time whether Ireland's test scores in science hold up after the introduction of the new JCA. Given the reduction in time and content in the new courses one might predict poorer performance. We will have to wait and see.



<https://edu.rsc.org/analysis/why-declining-science-scores-are-no-reason-to-panic/4011101.a>

PISA 2018 results

Snapshot of students' performance in reading, mathematics and science



Source: OECD, PISA Database || *B-S-J-Z refers to Beijing, Shanghai, Jiangsu and Zhejiang



40th Birthday greetings

From Professor Sean Arkins, Dean, Faculty of Science & Engineering, UL
Sean.arkins@ul.ie

It is a singular honour to mark the 40th anniversary of *Chemistry in Action!* and to celebrate the remarkable contributions of the magazine and its founding editor Dr Peter Childs. STEM disciplines have now found a ready public platform. There is acknowledgement that the developments in technology of the nineteenth and twentieth centuries owe their origin to the advances in these disciplines. Even in the face of the current global pandemic, there is acceptance that scientific and technological innovations will be increasingly important to society as we face the benefits and challenges of globalization and meeting our society's requirements in a sustainable manner. STEM disciplines and the teaching of these disciplines have thus come to the forefront of our teaching curricula, but it was not always so.

The University of Limerick had long been aware that Science teachers are an important constituency in our efforts to advocate the teaching of STEM subjects and, in particular, of Chemistry. As the largest producer of Science Teachers in Ireland, the University of Limerick had been very conscious of its central role in influencing how Science subjects are taught in Ireland's secondary schools. When Dr Peter Childs had the foresight to launch *Chemistry in Action!* in May 1980, his primary goal was to improve the teaching of Chemistry in Ireland through supporting and encouraging chemistry teachers. The title conveyed the belief and the excitement of the editor in his subject and also articulated his conviction that Chemistry should be taught, not as an inert subject on the pages of a

textbook, but one that should be brought to life in the laboratory and as a key discipline that is central to Ireland's industrial success. During the process, Peter developed a wealth of connections with Ireland's Chemistry teachers through the *Chemistry in Action!* magazine and through the Chemed-Ireland conferences, which were first launched in 1982 and are still going to this day.

Chemistry in Action! was made available free of charge to all teachers in print form until two years ago when rising production costs mandated the move to electronic format. Since then, its circulation has continued to increase, and it is acknowledged as 'a must read for Science teachers'. It is also a real testament to the quality of the magazine that its print production costs were met for 38 years by sponsorship from Ireland's Chemical industry. Forty years on and Peter Childs' enthusiasm for Chemistry and for the teaching of Chemistry has never wavered.

While no longer in a full-time faculty role at the University of Limerick, Peter remains more committed than ever to science education research and *Chemistry in Action!* He has never retired and remains a tireless advocate for Science teaching and, in particular, the teaching of Chemistry. On behalf of the community of Science educators it is a pleasure to salute the 40-year contribution of *Chemistry in Action!* and its Editor to the advancement of Chemistry education in Ireland. Congratulations and continued success.

□

Chemistry at the University of Limerick

J. Tony Pembroke

Chair of Industrial Biochemistry, Former Head of Department of Chemical Sciences and School of Natural Sciences, University of Limerick tony.pembroke@ul.ie

When I joined the then National Institute for Higher Education, Limerick in 1983 the flagship course in Chemistry was the BSc in Industrial Chemistry, housed within the Department of Materials Engineering and Industrial Chemistry (MEIC), within the College of Engineering. At that time there were some 20 students per year with no registered postgraduate activity but with a pioneering spirit of supplying graduates suitable for immediate industrial uptake and a co-operative placement system of paid work placement. Placement was somewhat untried at that time, but we soon began to see its advantage in supporting our teaching in applied chemistry and allowing our students to gain valuable industrial experience. Students go on co-op placement in their 3rd year for 8 months.

As the first graduates emerged it was observed that there was a need for a Graduate Diploma in Industrial Chemistry, which was a transition type programme where engineering, traditional chemistry graduates or graduates of other related disciplines, could transition to an applied career path. This programme ran from the mid to late 1980's when it had largely outlived its initial *raison d'être* and was discontinued.

Teaching using a trimester system was intense with an applied focus and at that time without repeat examinations. This coupled to a cumulative assessment system made life tough for the early chemistry graduates.

In the late 1980's three things happened that led to major changes for Chemistry. Firstly, the NIHE began to register postgraduates and Chemistry was to the fore. Secondly, because of the growing activity in biotechnology we began a BSc in Industrial Biochemistry, with first graduates in 1989 and modelled on the Industrial Chemistry programme. Both programmes shared large numbers of modules and also incorporated chemical engineering principles, which made both programmes unique. Finally, NIHE was granted University status in 1989, which began a period of major growth within the now University of Limerick.

The first PhD graduates in Chemistry and Biochemistry took place in 1989 marking a landmark push towards generating high calibre PhDs with an applied focus in Chemistry and Biochemistry, but at that time there were just a handful of postgraduates.

In the early 1990's Chemistry split from Materials Engineering and was a focal point for the new Department of Chemical and Life Sciences. This new department consisted of the faculty from Industrial Chemistry and Biochemistry, Chemistry Teacher Education faculty and Rural Science faculty from the amalgamation with Thomond College of Education. Industrial Chemistry and Industrial Biochemistry were at its core but there was an increased focus on service teaching.

The department began teaching chemistry to large numbers of Science Education students supporting the BSc Education with Chemistry. This activity included running chemistry pedagogy courses in the department laboratories and has influenced the teaching of science in schools nationally and internationally ever since. The department has been active also in hosting in-service courses for chemistry teachers, induction courses in chemistry for transition year students and participating in science and instrumentation programmes for leaving certificate students all supporting the teaching of chemistry.

As the 1990's progressed the Department underwent several further changes. There was a split from Life Sciences and a new department formed, the Department of Chemical and Environmental Sciences. This coincided with the development of a new BSc in Environmental Sciences with a Chemistry and Technology focus to meet the growing needs of environmental protection and licencing within industry. In the late 1990's the University of Limerick changed to a semester model, which allowed for many Erasmus student exchanges and allowed repeat exams, which facilitated progression for students who were ill during exams or for those who may have underestimated the need for study!

In the late 1990's the postgraduate population also began to increase, the focus on research, funding

and publication increased and a real increase in student numbers began to occur in all programmes. In the early 2000's because of the focus of chemistry activity in the pharma industry, the BSc in Industrial Chemistry was renamed Pharmaceutical and Industrial Chemistry and accredited by the Royal Society for Chemistry using the same focus on applied chemistry and chemical engineering but incorporating a new focus on pharma. At this time the department initiated a new BSc in Health and Safety, which emerged from a night-time accredited Diploma in Health and Safety at Work. This had a chemical process focus and filled a niche with new national industrial health and safety focus on health and worker welfare. However, with the recession in 2010 this programme was discontinued.

In the early 2000's the Department began to realise that with the growth of pharma and emerging biopharma industry there was a need for a conversion programme in Chemical Engineering, which led to the IChemE-accredited Graduate Diploma in Chemical Engineering. This attracted graduates from Mechanical Engineering, Chemistry, Biochemistry and Environmental Science and involved a 1 year conversion programme to Chemical Engineering. Following some 10 years' experience in running this Grad Dip which still runs today, the department decided in 2013 to develop our latest offering, the accredited BEng in Chemical and Biochemical Engineering. In 2015 we underwent one final name change and became the Department of Chemical Sciences, within the new School of Natural Sciences. The Department now has some 500 undergraduates with some 240 in Industrial Biochemistry and 120 on the BEng supporting the growth in Biopharma. There are currently some 110 registered PhD students within the Department, some 80% focusing on Applied Chemistry and 60 Postdoctoral Fellows supporting this activity.

The departmental research activity is supported with national and international competitive research and industrial funding, which is the highest within the entire university. This has led to the development of several research centres initiated by departmental faculty. These include the Solid State Pharmaceutical Cluster (SSPC), the Pharmaceutical Manufacturing and Technology Centre (PMTc) and many chemical and biochemical focused research programmes

within the Bernal Institute. This Institute is a €60M philanthropic investment in research activity incorporating state of the art chemistry and biochemistry laboratory facilities, instrumentation and 10 professorships (currently two in Chemical Engineering and one in Crystal Chemistry and Engineering).

So chemical education at the University of Limerick has come a long way since early 1980's. The applied focus is still a top priority as is our role in development of teacher education and pedagogy. We are experiencing increased CAO applications in all our programmes particularly Chemical and Biochemical Engineering, Environmental Sciences, Industrial Biochemistry and Pharmaceutical and Industrial chemistry, with all of them accredited and showing high industrial uptake upon graduation. The growth in research has led to a large increase in publications with several recently in *Nature*, *Science*, ACS journals and so on.

The Department and its associated research centres have put a big emphasis on outreach to schools whose pupils will form the next generation of our students. We see *Chemistry in Action!* magazine as an essential element of informing teachers and of engaging new students who will hopefully utilise chemical sciences and our facilities, built up over the past 40 years, to solve the next generation of scientific problems. These will range from climate, energy, pharma and disease, to developing chemical and process solutions.

Finally, it is gratifying to see and trace the careers of some of our graduates. Many have started their own chemistry, diagnostic or biotech companies and are now multi-millionaires. Many are now at senior management or director level in the top 10 Pharma and Biopharma companies throughout the world. Many have taken an academic route, completed PhD's at UL or world-wide and we now see them as professors in many of the world's top universities. Many are educators teaching chemistry to the next generation.

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Editor's note on science education at UL

The production of second level science teachers began in 1972 at Thomond College of Education, on the UL campus, with Physical Education with Chemistry. This option has now been

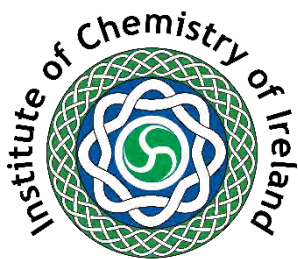
discontinued but over the years it produced some excellent teachers of science/chemistry. Your editor joined TCE to teach chemistry in 1978. Later the Rural and General Science Course started which produced teachers of Biology and General Science. After the merger with UL, this became BSc Education in Biological Science with either Chemistry or Physics. Later a BSc in Physical Science (Chemistry and Physics) was started. Much later in 2019 a PME in Science Education was launched in addition to the undergraduate courses.

In 2008 the National Centre for Excellence in Mathematics and Science Teaching and Learning (NCE-MSTL) was launched, which later became Epi*Stem, the Centre of Excellence for STEM Education in 2014. The first Professor of STEM

Education was Sibel Erduran in 2014, who was replaced by Marilyn Goos in 2018. The first designated lecturers in Science Education were appointed in 2019. However, many people have been active in STEM education over the years, including Peter Childs (Chemistry), Frank McGourty (Biology) and George McClelland (Physics), based in the science departments, with a strong group in Mathematics Education under John O'Donoghue. John O'Reilly, Orla McCormack and Geraldine Mooney Simmie, all in the Department of Education and Professional Studies, have also been involved in science education research and curriculum projects. John O'Reilly is the Chair of the Chemistry Development Group of the NCCA.

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From Professor Celine Marmion, President, Institute of Chemistry of Ireland and RCSI



On behalf of the Institute of Chemistry of Ireland, may I warmly congratulate you and your editorial team as you celebrate the 40th anniversary year of 'Chemistry in Action!'.

The Institute of Chemistry of Ireland is honoured to have had such a long association with this journal since its official launch in 1980 during the ICI Annual Congress, which was hosted by Sligo Institute of Technology. 'Chemistry in Action!' has become an invaluable and pivotal Chemistry resource for Chemistry teachers working in second level education in Ireland and beyond since then. It is a particular privilege to be asked to contribute to this 40th anniversary edition.

As you celebrate this important milestone, it is only fitting to stop and reflect on the impact of 'Chemistry in Action!' over the forty years since its first publication. Peter, in your wonderful editorial of the very first issue of 'Chemistry in Action' dated May 1980, I note that you highlighted that 'chemistry is first and foremost a practical subject' and that a particular focus of 'Chemistry in Action!' would be to 'stress a practical approach to the teaching of chemistry'.

You also highlighted the importance of applied chemistry and the need to build 'an awareness of the role of chemistry in everyday life, in society, in industry and in the Irish economy'. I was particularly taken by your words that 'Chemistry which is unrelated either to personal experience in a laboratory or to its applications in everyday life, can only be a superficial part of a child's education'. A second focus of 'Chemistry in Action!' was therefore to also promote an awareness of the applied nature of Chemistry in the real world, which would, in your words, 'surely enrich our teaching' and I couldn't agree more. You also noted the need for support and sponsorship to not only make this publication freely available to ICI and ISTA members but more widely to all secondary school Chemistry teachers both in Ireland and abroad. You asked the Chemistry community to support you in this wonderful venture by contributing 'articles, experiments, ideas for teaching, your personal views etc'.

From a review of the many editions of 'Chemistry in Action!' that have been published since 1980, it is abundantly clear that you have more than met your original objectives. 'Chemistry in Action!' is a vibrant and influential resource with key information and updates on chemistry education research and reports. It also includes stimulating articles on a wide range of applied chemistry topics and includes an extensive array of interesting experiments and ideas to inspire teachers to bring chemistry to life in their schools.

Your most recent edition which includes the ‘Annual Report on Chemical Education in the Republic of Ireland 2018-2019’, a wonderful article on ‘STEMming the tide: reflections on curriculum development in Ireland’, another on ‘Professional Learning Communities (PLCs) of Chemistry Teachers’ and on ‘Students’ use of graded learning aids for inquiry learning’, as well as an informative article on ‘The Antimicrobial Resistance Epidemic’ and ‘The Future of Solar Energy’, amongst many other interesting articles,

is testament to the quality of this publication and the wide ranging impact that it is having within and beyond our Chemistry community.

On behalf of the Institute of Chemistry of Ireland, may I again congratulate you and your editorial team and thank you for your unwavering dedication and commitment to supporting and inspiring Chemistry teachers. May I also wish you continued success with ‘Chemistry in Action!’.

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From Rachel Mamlok-Naaman, Chair, Division of Chemical Education, EuCheMS

Chemistry in Action! was launched in May 1980 at the Institute of Chemistry of Ireland's annual Congress in Sligo, aimed at chemistry teachers, chemistry educators, and chemistry education researchers. During these 40 years, the journal consisted of a variety of articles, annual reports on chemistry education, policy developments, outreach, up-to-date chemistry and chemistry education news and views (e.g., the international year of chemistry), studies on teachers, students and curricula, and a large range of teaching and learning materials.

The Division of Education at the European Chemical Society (DivCEd EuCheMS) disseminates European chemistry and chemistry education events through its website and newsletters. Therefore, *Chemistry in Action!* can be viewed as a significant and important

amplification to the outreach of chemistry education ideas and activities in Europe. Due to its high and scholarly quality, there is no doubt, that it has a significant impact on its readers, and its contribution to chemistry education is inestimable.

I would like to express my great appreciation to Dr Peter Childs, who launched *Chemistry in Action!* forty years ago, and since then has been its editor. His precise and dedicated editorial work, may be regarded as an exemplary model to real devotion to chemistry education, and especially to chemistry teachers.

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Science education

“We need science education to produce scientists, but we need it equally to create literacy in the public. Man has a fundamental urge to comprehend the world about him, and science gives today the only world picture which we can consider as valid. It gives an understanding of the inside of the atom and of the whole universe, or the peculiar properties of the chemical substances and of the manner in which genes duplicate in biology. An educated layman can, of course, not contribute to science, but can enjoy and participate in many scientific discoveries which are constantly made. Such participation was quite common in the 19th century but has unhappily declined. Literacy in science will enrich a person's life.”

Hans A. Bethe

Chemistry in Action! - An inspiration for ISTA members

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Introduction

I am delighted to have been asked by the ISTA to write this article to mark the 40th anniversary of *Chemistry in Action!*. The esteem in which Dr Peter Childs is held by science teachers is evidenced by the fact that he was invited to be Hon. President of the ISTA in 1995 and was also the recipient of the Science Educator of the Year award for his outstanding contribution to science education in Ireland.

Dr Peter Childs arrived in Ireland in July 1978 to teach chemistry at Thomond College of Education. He got down to work immediately and, over the intervening years, has established himself as a giant of science education in Ireland. In May 1980 he launched the first issue of *Chemistry in Action!* Over the years he has been an outstanding friend and supporter of the Irish Science Teachers' Association. He has always worked in close collaboration with the ISTA and, as a member of ISTA, has identified with its mission as a body dedicated to the professional development of its members and the advancement of science teaching.



Figure 1: Pictured at the presentation of a set of bound copies of *Chemistry in Action!* to Dr Peter Childs at the ChemEd conference held in UCC in 2011 were (left to right) Brendan Duane, PDST, Dr Peter Childs, Dr Declan Kennedy and Miriam Horgan, Chemistry Inspector. (Photo: Noel Brett).

There are two treasured possessions in the Eureka Resource Centre of UCC. One is a set of bound copies of every edition of *Chemistry in Action!* (Figure 1) and the second is a set of bound copies

of every edition of SCIENCE - the journal of the ISTA. In *Chemistry in Action!* Peter Childs has captured the development of chemistry education in Ireland over the past 40 years. Not only does the publication chart the development of chemistry in terms of curriculum reform but it also contains a wealth of resources that are used in the teaching of chemistry by our student teachers and those undertaking research at masters and PhD levels in UCC.

The great usefulness of *Chemistry in Action!* to all of us involved in science education is that its content ranges over such a wide variety of topics. In this short article, I will endeavour to try to give a flavour of where I see the strengths of having this outstanding publication available to all of us.

1. Topics in *Chemistry in Action!*

The ChemEd-Ireland conferences are among the finest CPD programmes that I have ever attended. I vividly recall as a young science teacher the excitement that I experienced year after year as I headed off early on Saturday mornings to Limerick and being so warmly welcomed at the registration desk by Peter Childs and Marie Walsh. I still retain that same excitement when heading off to ChemEd-Ireland each year. I applaud Peter and his team for always organising excellent ChemEd-Ireland conferences where I learned so much chemistry content and came home with lots of top-class teaching ideas to help me in the classroom. The fact that the proceedings of these ChemEd-Ireland conferences were always published in *Chemistry in Action!* added greatly to the quality of the publication.

Some of the topics which I recall as being among the great ingredients of the ChemEd-Ireland conferences and subsequent articles in *Chemistry in Action!* are:

- Overview of marking of the Leaving Certificate examination paper.
- Chemistry Demonstrations and Chemistry Magic Shows.
- "Hands on" practical laboratory activities.
- Resources available from PDST.

- Ideas on approaches to teaching a range of topics on the Leaving Certificate chemistry syllabus, e.g. bonding, environmental chemistry, development of atomic structure and organic chemistry.
- Technical tips for teachers in the area of laboratory organisation and management.
- New topics such as nanochemistry, potential for use of hydrogen as a fuel, the use of new technologies for carrying out laboratory practical work.
- RSC Resources and Spectroscopy in a Suitcase.
- Teaching Transition Year chemistry.
- Laboratory practical work and its assessment.
- How to motivate and engage chemistry students.
- Science, Technology and Society. This is an area in which I have always been interested and found the articles on famous scientists gave me great background information to help me explain the scientific method and interest my students in chemistry, e.g. Amadeo Avogadro, Robert Boyle, Justus von Liebig, Dmitri Mendeleev and Linus Pauling,
- Industrial chemistry. I recall attending several industrial visits organised by Peter during the summer, e.g. visiting Tara mines, IFI Arklow and Premier Periclase in Drogheda. Details of these industrial visits were subsequently published in *Chemistry in Action!* and served as great resources for teaching this part of the syllabus.

In addition to covering topics at Leaving Certificate chemistry level, *Chemistry in Action!* also covered issues related to Junior Cycle science, e.g. the issue of teaching science at a common level.

In shoes and clothes one size does not fit all. The move to a common level course and examination in Junior Cycle Science implies that one size does fit all when it comes to education. This is clearly not the case as any parent or teacher will tell you. Children vary widely in their ability and interests. In the past teachers had problems teaching Higher and Ordinary level students together. Trying to fit a course and an examination to all students over the whole ability range inevitable

means aiming at the lowest common denominator. (Childs, 2019)

Peter also points out in the above article that a common level at Junior Cycle science "exposes the weakness in Irish curriculum development that everything is controlled by one body, the NCCA, which has not shown itself very responsive to criticism, e.g. by the ISTA and the Hyland Report on the new LC science specifications. No other body is allowed to design or approve or offer a school course or introduce a new syllabus".

He also gives some examples of very innovative and imaginative courses that have been developed in other countries, in order to give teachers a variety of curricula that they can choose to teach, e.g. the Salters courses and 21st Century Science course in the UK. He comments that "these were all the produce of what we might call private initiative, funded by charitable bodies, and competing in the marketplace with other syllabi for students. Even then teachers and schools have a choice of multiple science syllabi from four examination boards, giving schools great freedom to tailor their subject offerings to their own needs". (Childs, 2019).

Peter was one of the first to express concern about the fact that chemical bonding is not mentioned on the Junior Cycle science specification and commented that "it is an essential idea in chemistry and one of the key ideas that should be covered in introductory chemistry". In an excellent article entitled *Chemists love making bonds*, (Childs, 2015) he showed how this foundation stone of chemistry can be easily taught in an introductory chemistry course.

2. The international dimension of *Chemistry in Action!*

Chemistry in Action! keeps us informed of interesting research projects taking place at international level, e.g. the *TEMI* (Teaching Enquiry with Mysteries Incorporated) project; the *PROFILES* (Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science) project; the *Chemistry is All Around Network Project* to encourage lifelong learning in chemistry. All these projects are EU-funded, have Irish partners and have produced excellent resource materials to help chemistry teachers in the classroom. By highlighting these and many other international projects, Peter has made us aware of the fact that many of the

chemistry topics we teach are similar to those found in other countries and that many of the teaching strategies developed abroad can also assist us in teaching chemistry in Ireland.

Over the years there have been many interesting articles submitted by chemistry teachers from abroad, e.g. articles on the *Nomenclature of Organic Compounds* by Ingo Eilks (Germany), *Microscale Chemistry* by Bob Worley UK and Victor Obendrauf, Austria, *Nanotechnology* by David Katz (USA) and *Approaches to Teaching Chemistry* by Avi Hofstein (Israel) and Marc Stuckley (Germany).

Many of these were speakers at ChemEd conferences and subsequently wrote up their lectures for *Chemistry in Action!*

In particular, I was hugely impressed by the work being done by David Waddington, Judith Bennett and John Holman at the University of York and spent many wonderful years working with them and their colleagues there. Judith Bennett and David Waddington have both spoken at ChemEd-Ireland conferences, along with the late Alex Johnstone.

3. Role of Practical work in teaching chemistry

There has always been a great emphasis in *Chemistry in Action!* on the important role that practical work plays in chemistry education. I can clearly recall outstanding demonstration lectures at ChemEd conferences by Randal Henly, John Daly and Victor Obendrauf, as well as great chemistry workshops run by Brendan Duane and his PDST team. I am saddened to see evidence emerging from the recent ISTA survey (ISTA, 2019) of some teachers expressing concern that the lack of clarity on what practical work should be carried out by students is leading to less practical work being done by students in the new Junior Cycle specification compared to the old syllabus.

This is my biggest frustration with the course - all of the practical work that we used to do I'm no longer doing but I haven't replaced it with anything.

The new JC science needs to address the lack of practical work and become clearer in the outcomes it wishes us to teach.

We as a department feel that we are doing less practical work than before.
(ISTA, 2019)

This concern was also expressed in a recent letter written to the *Irish Times*.

The lack of specifications for required practical work in junior cycle science appears to have led to a reduction in practical work in some schools, and a list of mandatory experiments was brought in previously to guard against this. (Childs 2020)

Clearly one of the great advantages of a mandatory list of practical work is that it ensures that all students carry out a minimum amount of practical work and this develop a common set of basic laboratory skills. I look forward to seeing this topic discussed in future issues of *Chemistry in Action!*

4. Key articles on curriculum reform in *Chemistry in Action!*

Throughout the 40 years of publishing of *Chemistry in Action!*, Peter has always attempted to ensure that chemistry teachers in Ireland were kept in touch with developments in chemistry education at international level.

When the Hyland Report was published in 2014, a total of nine pages were devoted to discussing it in *Chemistry in Action!*. One of the interesting suggestions made by Professor Aine Hyland (Hyland, 2014) was that consideration be given to national and international collaboration in the sharing of syllabus documentation: *"In coming to a decision about the detail to be provided for the Leaving Cert examination syllabi, consideration might be given by the Minister to collaborating with other bodies, either nationally or internationally to provide appropriate state-of-the-art materials thereby avoiding unnecessary and expensive duplication or 're-inventing the wheel'. As science subjects are less culturally bound than some other subjects, resources developed for science teaching in one country are likely to be relevant and suitable for teachers and learners in another country. All the documentation accessed for this report is in the public domain, and is accessible for anyone (teacher or pupil or member of the public) who wishes to use it."* (Hyland, 2014, p. 44)

Through his editorials and articles in *Chemistry in Action!* Peter shows a fundamental understanding of the importance of carrying out curriculum reform in a structured and transparent fashion as recommended in the Hyland Report. In his very analytical comments on the Hyland Report (Childs, 2014) Peter pointed out that curriculum development involves much more than listing

learning outcomes and emphasised that there are four main components of the curriculum (Figure 2):

- **Content** - what is taught
- **Pedagogy** - how it is taught
- **Learning Outcomes** - what it is expected that the student will be able to do
- **Assessment** - how we assess students' learning to see if they have achieved the learning outcomes



Figure 2: The curriculum components (Childs, 2014)

In a subsequent editorial (Childs, 2015) entitled *How not to do curriculum reform* he summarises some lessons to be learnt from the way curriculum reform has been done in the past. Among the list of key lessons that he lists are:

- *Don't take account of what has been learnt from science education research over the past 30-40 years.*
- *Don't pilot new ideas or content or methods and when there is a pilot study, don't wait for it to be fully evaluated before implementation.*
- *Don't listen to the views of and criticisms by science teachers on the draft curriculum.*
- *Don't issue sample exam papers until the last year of the course.* (Childs, 2015)

Peter has not confined his talents and expertise to writing solely for *Chemistry in Action!* and other academic publications. I was greatly impressed by

Peter's ability to summarise and synthesise the key points of the current debate about curriculum design in Ireland in a letter recently published in the *Irish Times* (Childs, 2020)

Prof Hyland showed in her 2014 report for the Irish Science Teachers' Association that a "syllabus" based only on learning outcomes (statements of what students should know), does not reflect best international practice and does not provide an adequate framework to allow teachers to teach the course.

It is like trying to build a house based only on its desired features, but without an architectural drawing and detailed plans. Teachers need a detailed syllabus, like the ones currently used, in order to teach effectively – this includes detailed content specification, depth of treatment for ordinary and higher level, suggested or mandatory experiments, as well as clearly stated learning outcomes.

If the same mistakes are made with the Leaving Certificate sciences that were made with the junior cycle science course, I believe it will have serious consequences for the health of STEM (science, technology, engineering and mathematics) education at second level, with a knock-on effect on STEM enrolment at third level.....

It is a recipe for disaster when teachers do not know what they are supposed to teach and to what depth, where each teacher becomes the arbiter of the curriculum.

This is not a good basis for a rigorous STEM foundation for future courses and careers.

The Government and industry rightly want to promote STEM courses and careers, to underpin our successful STEM-based industries.

Allowing outcomes-only Leaving Certificate science specifications to be introduced, without the necessary supporting materials – and against the advice of science teachers, science education specialists and scientists – is a recipe for future failure.

The foundations of a STEM-based economy are in real danger of being weakened and undermined. (Irish Times 28/1/20)

Peter has been a pioneer in using *Chemistry in Action!* to keep teachers informed of developments in chemistry education throughout the world. In this short article it is not possible to

even give a summary of the many such articles but one article, in particular, springs to mind as being highly relevant to the development of new syllabi in Ireland. This article *What are the big ideas in Chemistry?* (Childs, 2014) gives an overview of international studies on the range of fundamental concepts that should be contained in second-level chemistry courses. This is highly relevant to the present circumstances in which a new Leaving Certificate chemistry specification is being developed and should be recommended reading for all members of Leaving Certificate chemistry and Junior Cycle science subject development groups.

Conclusion

Words fail me when I try to describe the enormous contribution that Peter Childs has made to science education in Ireland for over 40 years. I have always been in awe of his wisdom, common sense, boundless energy and breadth and depth of knowledge of chemistry possessed by him. Through his close contacts with practising teachers he has shown himself to have a crystal-clear understanding of the concerns of teachers regarding curriculum reform. Through his lectures and writings, he has openly demonstrated that he is on the side of teachers in their efforts to ensure that we have science curricula in Ireland that are comparable with international syllabi around the world. I know that Peter is a man of great faith and my greatest wish for him is that God will continue to bless him with good health so that we will all celebrate with him the 50th anniversary of the publication of *Chemistry in Action!*

What is science?

“Science is a many-sided, often cacophonous rag-bag of claver men and women and worthwhile projects, following trails and false trails, exploring, hypothesising, and testing.”

Matthew Parris *The Times* 25/4/20

“Unthinking respect for authority is the greatest enemy of the truth.”

Albert Einstein

“We must reason in natural philosophy not from what we hope, or even expect, but from what we perceive.”

Humphry Davy (1778-1829)

References

Childs, P.E. (2014), Education News and Views - The Hyland Report? , *Chemistry in Action!*, 103, 3 - 11.

Childs, P.E. (2014), What are the big ideas in chemistry? , *Chemistry in Action!*, 104, 6 - 12.

Childs, P.E. (2015), How not to do curriculum reform , *Chemistry in Action!*, 105, 2

Childs, P.E. (2015), Chemists love making bonds , *Chemistry in Action!*, 106, 27 - 34

Childs, P.E. (2019), Junior Cycle Science , *Chemistry in Action!*, 114, 2.

Childs, P.E. (2020), We need clarity on Leaving Cert science , *Irish Times* 28th January 2020.

Hyland Report (2014). Available at: <https://www.ista.ie/the-hyland-report-2/>

ISTA (2019) Listening to the Voice of Science Teachers. Available at <https://www.ista.ie/jc-science-report/>

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Biography

Dr Declan Kennedy is Senior Lecturer in Science Education at UCC. Prior to taking up his appointment in UCC in 1999 he taught science at secondary school level for over 20 years. He is the holder of an MSc and HDipEd from UCC and also an MEd and PhD from the University of York, UK.

Editor: Declan tells me that he has attended ChemEd-Ireland from the start in 1982, with an attendance record of 95%.

Developments and Issues in Science Education and Science Education Research 1980 – 2020

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(Based on a talk originally given at the ISTA Annual Meeting, Waterford, March 2002; revised 4/11/08 and 10/4/20)

Introduction

The purpose of this article is to give an overview of the development of science education and science education research (SER) in Ireland since 1980. Having been around and involved for all this period I can say that there has been a massive increase in the emphasis on and output of science education research over that time. Here are some of the major changes in science education and SER in that period.

- The output of PhDs and Masters' degrees in science education has increased;
- Ireland has been a major player in EU-funded projects, especially in the last 15 years;
- Several centres for STEM education have been launched at Irish third level institutions;
- Irish academics are more prominent in international science education conferences;
- The number of publications in academic SER journals from Ireland has increased;
- The number of courses producing second-level science teachers has increased, especially concurrent courses, and there has been an overall increase in the number of science teachers being produced;
- There has been a change from consecutive one-year H.Dip.Ed to two-year PME courses (giving a Masters' qualification);
- There has been the recent introduction of 5-year concurrent teacher education courses, giving a Master's qualification.
- Formal teacher registration has been introduced through the Teaching Council, who determine the criteria for teacher registration.

Irish researchers have been successful in winning research grants, national and international, and in winning national and international recognition. At the start of 2020 we would have to say that SER in Ireland is in a healthy state and activity in this area has greatly increased since 1980.

Science teacher education

A major sign of progress since 1980 is the number of courses, concurrent and consecutive, producing second-level science teachers. In 1980 all the traditional universities offered one-year FT Higher Diplomas in Education (TCD, UCD, NUIM, NUIG, UCC) and this was the main route to becoming a science teacher. Numbers were relatively low as entry to the courses depended on first degree classification, rather than the needs of the subject. The physical sciences were particularly under-represented in such courses. In 1980 UL and in 1999 DCU also started producing science teachers by the concurrent route through a 4-year FT degree, including in UL a degree in PE with Chemistry, which had started in 1972.

In 2020 the landscape has changed dramatically with a large increase in the number of science teachers being produced. The HDipEd has now been replaced by the 2-year FT Professional Masters' in Education (PME), following on from a 4-year honours degree. This is offered by NUIM, NUIG, TCD, UCD, UCC, UL, and DCU. Concurrent courses now come in two flavours: 4-year FT (UL, DCU, UCC) and 5-year FT (NUIM, UCD). In addition, a PT distance learning course is offered by Hibernia College. This means that the school leaver who is considering science teaching as a career has a choice of a 4-year or 5-year FT concurrent course or a 6-year programme (4 years for a primary degree plus 2 years for a PME), all resulting in the same teaching qualification. One area that needs research is the

comparative strengths and weaknesses of these different approaches to producing science teachers, since they nominally come out with the same qualification, albeit by greatly different routes. Concern continues to be expressed at the number of teachers of the physical sciences being produced, especially Physics, through commentators often overlook the concurrent courses and focus only on the consecutive courses. The concern about numbers taking the physical sciences in second-level, and the perceived shortage of physical sciences teachers, was one of the main reasons for the Task Force on the Physical Sciences set up in 2000, reporting in 2002.

There is still a shortage of science teachers, despite the numbers produced, because of the changes in employment conditions and lack of FT jobs following the 2008 recession, so that teaching in Ireland has become unattractive. Consequently many science teachers go abroad after graduation.

Increased emphasis on STEM education

For most of the period 1980 to 2020 science education was not seen as being important politically. The first signs of recognition of the importance of what is now called STEM education was the Task Force on the Physical Sciences (2000-2002), convened to address the perceived shortage of students taking the physical sciences at school and hence in third level.

Task Force on the Physical Sciences (2002) DES
<https://www.gov.ie/en/publication/908f50-task-force-on-the-physical-sciences-report-and-recommendation/>

A similar review group was set up in 2014, the STEM Education Review Group, STEMERG, to look into STEM education and reported in 2016, although the membership of the group was not as broad as that of the earlier Task Force.

STEM Education in the Irish School System (2016) DES

<https://www.education.ie/en/Publications/Education-Reports/STEM-Education-in-the-Irish-School-System.pdf>

This report led to the government's 10-year action plan for STEM education.

STEM Education Policy Statement 2017-2026 (2017) DES

<https://www.education.ie/en/The-Education-System/STEM-Education-Policy/stem-education-policy-statement-2017-2026-.pdf>

Other relevant government reports have looked at skills shortages. An earlier pertinent report was the 1985 Wilson Report on Inservice Education, which was never implemented.

The Irish Council for Science Technology and Innovation (ICSTI) was set up in 1997 and ran until 2005. One of its successes was the setting up of Science Foundation Ireland (SFI) to fund science research. It produced several important reports in its short life:

- *Science in Primary Schools* September 1998

Science in Second Level Schools November 1999
Benchmarking School Science, Technology and Mathematics Education in Ireland Against International Good Practice February 2000(<http://web.archive.org/web/20021219022343/http://www.forfas.ie/icsti/>)

ICSTI also produced a number of Technology Foresight Reports (1998-1999) and these led to the government setting up Science Foundation Ireland (SFI) in 2000, which was established on a statutory basis in 2003. (<https://www.sfi.ie/about-us/about-sfi/history/0>)

Since 2000 the government has invested large sums of money in SFI to fund applied and basic research, in addition to funding through HEA, IRC and other government bodies. This has had major implications for STEM education because the investment has created large numbers of research posts in Ireland, increasing Ireland's research output and number of research degrees produced. SFI has been one of Ireland's major success stories in the last 40 years, but relatively little money has been invested in SER or science curriculum development. However, in recent years a number of science education students have been funded to do research through the Irish Research Council (IRC, formerly IRCSET and IRCHSS), competing with science, technology and humanities students.

"The Council is an associated agency of the Department of Education and Skills and operates under the aegis of the Higher Education Authority. It was established in mid-2012 following the merger of the Irish Research Council for Humanities and Social Sciences (IRCHSS) and the Irish Research Council for Science, Engineering and Technology (IRCSET)."

Everyone in government and industry now talks about the importance of STEM education, and also about the gender balance in STEM subjects at

school and third level, but this is still not apparent in the practical support for STEM education e.g. still no technicians in schools; science in the junior cycle not compulsory and has been reduced to 200 hours; patchy resourcing of science in schools; poor careers advice on STEM careers.

What is IASEL?

IASEL is the Irish Association of Science Education Lecturers. It is an association of those people involved in science education in Ireland, particularly in the training of science teachers – either by the consecutive model (H.Dip.Ed. now PDE) or by the concurrent model (B.Sc. Education). It includes faculty from Irish universities and colleges, North and South. It was set up in 2000 to provide a forum for those involved in training science teachers and in science education research, to meet and share ideas, and to allow for a concerted voice to government etc. on issues concerning the training of science teachers. IASEL had originally included lecturers in both second level and primary science education. It lapsed around 2005 and was revived in 2015, to act as a voice for science education. In 2019 a separate Irish Association for Primary Science Education (IAPSE) was launched.

https://www.dcu.ie/stem_education_innovation_global_studies/news/2019/Nov/Irish-Association-for-Primary-Science-Education-Launch.shtml

The Task Force in the Physical Sciences was set up in Nov. 2000 but included nobody representing those people involved directly in training science teachers or SER. This oversight indicated low awareness of SER or how science teachers were trained. Following representation, IASEL was allowed to nominate a member to correct this oversight and I joined the Task Force in Nov. 2001, one year late, and in the final phase of its work.

IASEL initially held two meetings a year in September and March, often in conjunction with ISTA conferences, and meetings rotated around the various institutions. It has members from the institutions offering the H.Dip.Ed. (NUIG, UCC, UCD, NUIM, QUB, TCD) and those offering a concurrent BSc Education (UL, DCU, St. Angela's, St. Patrick's, MIC), as well as DLIADT.

As well as sharing ideas and information on the training of science teachers, IASEL also tried to

encourage science education research and to make practising science teachers more aware of the opportunities to do research and of the value of science education research in their everyday work. This talk was originally titled: "How science education research can help science teachers." IASEL also made representations to government and the NCCA on new syllabi. Such a voice is still needed in the corridors of power.

The state of science education research in Ireland

How do we measure the health of science education research in Ireland and its development over the last 40 years? There are number of possible ways:

- a) The number of people involved in science education research (as distinct from education research in general);
- b) The number of published papers in science education originating in Ireland in national and international journals;
- c) The number of education theses completed annually in Ireland in the area of science education, especially PhDs;
- d) The number of curriculum development or other projects in science education, especially those with external funding;
- e) The number and activity of dedicated science (STEM) education centres;
- f) The number of awards, national and international, achieved in science education.

It is not easy to get data on all these measures, but if we consider measure c) the number of theses produced annually, then this can be accessed. The Educational Studies Association of Ireland (ESAI) used to publish an annual list of education theses, which is available on the internet at <http://homepage.eircom.net/~eai/theses/theses.htm> and covers the years 1993-2000, eight years in total. From the titles of the theses from 1993-2000, we can identify those dealing with science education. In this period a total of 44 theses was identified, of which 26 (59%) were completed in institutions in Northern Ireland. In one year, 1999, of a total of 139 completed theses, 11 were in science education i.e. 8%. However, it is obvious from the list that the number being produced in the Republic of Ireland is much greater in recent years (10 out of 11 in 1999).

In the more recent years TCD i.e. Philip Mathews, has been the greatest provider and I believe these are a product of the M.Sc. course in Science Education, which runs every two years. He has now been replaced by Dr Colette Murphy, formerly at Queen's University, Belfast. In the 1980s Oliver Ryan at UCG (now NUIG) ran an MSc course and this produced many science-related theses. The course became a general MEd course and the number of science students dropped. An MSc course currently on stream at UCC will also result in a significant number of theses in science education. Queen's (QUB) has also produced a large number of MEd theses over the years. Dublin City University (DCU) has also started an MSc in Science Education. Sligo IT also ran a Masters in Science Education for 2 cycles, and in 2018 Mary Immaculate College, Limerick started a Masters in Science Education, and in 2019 the University of Limerick started a PME with Science Education as an option. Apart from these, only small numbers of individual research theses have been produced from individual colleges, although this has increased in recent years.

From 1993 to 2000, 4 PhDs were listed (1 in NI). Since 2000 the listing of PhD theses shows that UL (20) and DCU (20) have been the major producers, especially since 2005, with DCU also produced 9 Masters. (Note: These figures are incomplete and the main thing they show is that SER activity has increased in a major way since 2000.)

In addition, those institutions running the concurrent programmes e.g. UL and DCU, produce large numbers of Final Year Projects (FYPs) each year, many in science education, but these are not usually published or reported outside the home institutions.

Since 2000 there has also been a growth in STEM centres, which have increased Irish activity in SER, produced many research degrees and papers, increased participation in European projects, supported undergraduate programmes and worked with science teachers. These are listed below in Table 1.

Table 1: STEM centres in Ireland **Calmast, Waterford Institute of Technology**

Centre for the Advancement of Learning of Maths, Science and Technology
Sheila.donegan@wit.ie and eoin.gill@wit.ie

CASTeL, DCU

Centre for the Advancement of STEM Teaching and Learning
www.castel.ie
eilish.mcloughlin@dcu.ie

CERT, Technological University, Dublin

Chemistry Education Research Team
Claire.mcdonnell@tudublin.ie

EPI*STEM (formerly NCEMSTL), University of Limerick

National Centre for STEM Education

CERP, University of Limerick

Chemistry Education Research Group
Peter.childs@ul.ie

Eureka Centre, University College, Cork

Eureka Centre for inquiry-based education in science and mathematics
d.kennedy@ucc.ie

STEM-ERC, TCD, School of Education

Science, Technology, Engineering Mathematics: Education, Research and Communication

NUIG, School of Education

Centre for Pedagogy and Public Engagement Research, School of Education
Veronic.mccauley@nuigalway.ie

Most of the centres, of which CASTeL is the largest, deal with all levels of STEM education, but Calmast has a strong emphasis on primary and maths education and CERT in third level Chemistry education.

These centres are now well established and are active in research, in running courses and workshops for teachers, in participating in European projects and in publishing.

Irish institutions have been involved in many EU projects especially since 2005 and some examples are given below, with the participating institutions. In 2017 DCU and UL jointly hosted ESERA, Europe's largest SER conference.

Table 2: Some EU-funded STEM projects (since 2005)

(This list is necessarily incomplete but gives an idea of Ireland's participation.)

Tempus SALiS UL 2010-2012

FP7 TEMI 2014-2016 UL

Erasmus+ ARTIST 2016-2019 UL

RACE, EIT, 2017-2018 UL (coordinator)

Chain Reaction, FP7 2013-16, UL

Energie, Iterreg, 2019-2022, DCU & NUIG (coordinator)

ATS-STEM Erasmus + 2017-2019, DCU (coordinator)

3DIPHE, Erasmus+, 2017-2019, DCU

OSOS, H2020, 2017-19, DCU

SAILS, FP7, DCU (coordinator)

ESTABLISH, FP7, 20-10-14, DCU (coordinator)

INSTEM, Comenius, 2013-16, DCU

Newton, H2020, 2016-19, DCU and NCI

Tealeaf, Erasmus+, Newton Project, H2020, 2016-19, DCU

SOPHIA, Comenius 2005-9 DCU

Fibonacci, FP7, 2010-12, St. Patrick's College, Dublin

PROFILES, FP7, UCC

Problems in science education research (SER) in Ireland

In this section I want to try and identify some of the problems hindering SER in Ireland.

a) Lack of research funding.

It is very difficult to raise funds to support projects and students doing science education research. Most of the work that has been done is due to teachers doing it in their spare time and at their own expense. It is much easier to get funds to run courses or for in-service activities than to fund science education research. However, one example of funded research would be the Promotion of Chemistry in Schools Project at UL funded for three years by IPCMF. Several students have been funded by IRCSET (now IRC) in recent years. The EU-funded projects have also enabled many Irish students and teachers to do SER projects.

b) Lack of publication of research.

Despite the number of theses completed in Ireland, now a significant number, much of the research has either not been published or not made available to teachers and the wider

community. I suspect that much useful materials and important findings are languishing in university libraries, especially from final year projects. I am guilty here myself as I have had students who have done useful work, which has not been published and made available. Since 2005 there has been a welcome increase in research degrees and publications.

c) Lack of dissemination to teachers.

Even if the research is published, most science teachers do not read science education journals and thus do not see what is being done. The purpose of research is to provide new knowledge to illuminate the processes of teaching and learning or to provide solutions to problems in science education or to answer questions. Unless the results of research are communicated to practising teachers then any findings are still-born and ineffective in changing the practise of science teaching. Many science teachers may never read a paper or book in science education after they graduate. In addition to research articles, the results of the many EU-funded projects are not widely available to teachers apart from the few directly involved.

d) Lack of coordination and cooperation in research.

To a large extent each institution in Ireland does 'its own thing'. There is little cooperation or collaboration in research between, and perhaps even within, institutions. One result is that the same topics are being researched over and over again by different teachers in different places, without ever being published, disseminated or shared. I know that in recent years I have had several requests for help from teachers researching the decline in numbers doing chemistry and the reasons for it. We need more collaboration in joint projects, cooperation and sharing of results in order to progress the cause of science education in Ireland.

e) Lack of knowledge in important areas of science education.

There are many things we don't know about the state of science education in Ireland, and even if the research has been done, no-one may know about it except the person who did it and their supervisor. Much research has been done in other countries on the problems of teaching and learning in various sciences, and although much of it may be transferable to Ireland, the comparable research hasn't been repeated here.

This means that we don't know the answers to important questions. For example, we don't know who teaches science in Irish second-level schools, what their qualifications are and how they were trained, and what subjects they teach. This was one of the questions raised at the Task force and they came up with the total number of science teachers of just over 3,000. The Teaching Council has collected some of these data. We also have no idea of the strengths and weaknesses of the different models for science teacher education.

f) Lack of research and evaluation in curriculum development

Recent developments in the science curriculum – the new Junior Science Course, the new LC Agricultural Science specification and the proposed new LC Biology, Physics and Chemistry have highlighted the weaknesses and problems of curriculum development in Ireland. The NCCA is responsible for curriculum and assessment and reports to the Minister of Education. The SEC is responsible for setting the state examinations based on the agreed syllabi. The new curriculum framework adopted by the NCCA has resulted in subject specifications, not syllabi, with a dearth of detail on depth of treatment, suggested practical work and other materials to help teachers teach effectively. The NCCA has focused on a model based almost entirely on learning outcomes, leaving teachers at sea as to what to teach. New curricula are developed and implemented without piloting and without any real evaluation. The real concerns from science teachers about the new Junior Science course (now offered at one level), the new Ag. Science course and the proposed new LC Biology, Chemistry and Physics courses, have not been listed to. The lack of choice of alternative, competing syllabi in a subject (unlike the U.K.) is also a weakness of the Irish system. This may well see increased adoption of the International Baccalaureate (IB) courses.

The use of science education research by the science teacher

What use is research in science education to the science teacher? This is an important question. Many teachers believe that educational research has no relevance in the everyday classroom or in laboratory teaching, and very often they have a point. SER is seen as being abstract, abstruse, airy-fairy, irrelevant, off-the-wall nonsense. We must admit that not everything in SER is relevant, not everything is useful, and not everything is right that sees the light of day in publication.

Someone once said that 80% of science research that is published is eventually shown to be wrong, but that doesn't make science research useless. But one still has to search for the gold among the dross and the same is true of SER.

For the individual science teacher one major driving force to doing research is the extra salary increments that accrued from a Masters or Doctorate degree (sadly no longer the case.) Even though such degrees are quite costly in fees, travel, time commitment etc., there was usually a net profit over a teacher's lifetime. There is also the personal reward of achievement and status is completing a higher degree. In addition, doing research and becoming acquainted with the research literature, almost certainly has a major beneficial effect on one's own teaching. (This is an area where research is needed on the impact of doing SER on an individual's science teaching.) Working for a higher award – diploma, masters, doctorate – should be a major aspect of in-career development for the teacher. The work involved in reading, researching and reporting is a valuable component of professional development. Compared to 2000, or 1980, there are many more science teachers in Ireland who have completed Masters and PhDs, often in STEM or other related aspects of Education.

Research may be the only way to answer particular questions, or to solve problems, unique to Ireland or to a particular area or school. Science advances through research and the application of new knowledge, in a cumulative, self-correcting process of advancement. The same is true of science education research, a subset of education research in general. If we don't do the research, we won't know the answers, and we may not be able to solve the problems. We will also not be able to use an evidence-based approach to teaching and learning, and follow best international practice.

However, I must say that much science education (or education) research is not relevant to the practising teacher. It is too theoretical, too academic, too full of jargon, and too unrelated to real-world problems, and is often produced to further the researcher's academic career. We need more translation and more communication of helpful research findings in a language and format that teachers can use.

How can we improve the situation?

Here are some personal recommendations as to how we can improve science education research in Ireland and the utilisation of such research by teachers.

1. Make more teachers aware of the value of science education research in their everyday classroom teaching. This should be introduced in their initial teacher training and continued as CPD through in-service courses, workshops and periodicals.

2. Ensure that all science education research done in Ireland is published to make it available and that summaries of such theses are published in *Science and Chemistry in Action!* to alert teachers. Much of what SER is done is never read by teachers and there is a major information gap in this area.

3. Make sure that the results of relevant science education research done inside and outside Ireland are disseminated to teachers.

- through conferences and lectures e.g. at ISTA meetings
- through targeted publications like *Science and Chemistry in Action!*
- in DoES and NCCA documents
- in in-service courses by the PDST
- in syllabus guidelines and design of examinations
- etc.

4. Encourage more science teachers to do research, especially action research (see the ARTIST project) as part of their in-career development and make sure they are funded and recognised for this work.

5. Set up an Education Trust Fund with monies from industry and government to fund science education research and curriculum development and other projects in science education. Alternatively, part of SFIs budget should be specifically targeted at SER, not just at education and outreach, following the model of the NSF in the USA.

6. Make sure postgraduate funding through IRC is equally available to science education projects as to research in other areas, and provide funds for teachers to attend international conferences.

Opportunities for science education research by Irish science teachers

Coursework and thesis: several institutions offer MScs/MEds by coursework and thesis e.g. NUIG, QUB, TCD, UCC, MIC, SligoIT*, TraleeIT*. These are part-time courses, run in the evenings and at weekends or in holidays, part-time over two years. The second year is usually devoted to the research project. (*courses now suspended)

Thesis only: most universities offer the option of doing a masters or doctorate (subject to qualifications) in science education by research only. This can be full-time or part-time and an increasing number of teachers and newly-qualified teachers are taking this route.

Distance-learning: the Open University in the UK offers a Masters in science education by distance learning. A number of Irish teachers have done the course.

Residential courses: some UK universities offer a short residential FT course e.g. York, East Anglia, with the option to upgrade to a Masters' of PhD by thesis, which is then done part-time. A number of Irish teachers have done these courses and completed PT research degrees.

Since this article was first written in 2000, many Irish science teachers have completed Master's degrees or PhDs, which can only be beneficial individually and to the teaching profession.

Organisations, publications and conferences in science education

A number of international organisations (ESERA, ICASE, EuCheMS) promote science education research and there are many publications for science education research. Some organisations have published statements defining science education, or its sub-disciplines chemical education, biology education and physics education. There are opportunities for teachers and researchers to attend and present their work at international and national conferences, e.g. ESAI conference in Ireland; ESERA (met in Dublin in 2017); Eurovariety and Irish Variety for 3rd level lecturers (chemistry); ECRICE (chemistry); GIREP (physics) etc.

In 2006 DCU started the SMEC conferences, a research-focused conference, which have run every two years since then. ChemEd-Ireland was started in 1982, initially in TCE, then in UL, and

is an annual conference for Chemistry teachers, with the aim of equipping Chemistry teachers by providing professional development. It now rotates between several third level institutions with an interest in science education: UL, LIT, DCU, UCC, TUD and TCD. The ISTA has an annual conference, and also organises regional lectures and workshops for teachers. Each of these conferences, especially SMEC, has provided opportunities for teachers to present their research to other teachers and researchers, but this is an area that could be developed further.

Two National Chemistry Weeks were held in 1988 and 1990. Such National Chemistry Weeks are an annual event in the USA and UK, but sadly not in Ireland.



In 1996 National Science Weeks were started, held in November, and now coordinated by SFI. These have become important annual events promoting STEM. Similar weeks are now held for Engineering and Mathematics. In addition, Galway has a long running Science Week, and UL ran a number of Science Fairs.

The Young Scientist's Exhibition (YSE) was started in 1965 and was sponsored by Aer Lingus for many years. It is now sponsored by BT and goes from strength to strength; it is one of the world's longest running science fairs. It is Ireland's premier Science Fair and an important feature of the STEM calendar. In recent years it has been joined by SciFest, which involves primary and secondary students, is based on regional competitions feeding into a national final. This competition involves large numbers of students, teachers and schools. The RDS also runs a science fair specifically for primary students. In

the past individual companies have run regional science fairs, e.g. MSD in Co. Tipperary. (For a more detailed look at science outreach see the article by McHugh and Hayes, due to be published in issue 116).

Conclusions

I hope you now have a better appreciation of the state of science education and science education research in Ireland, of the problems involved in increasing the output of useful science education research, of the value of such research to the teacher and the opportunities to pursue such research and develop one's career in Ireland.

It is important for the practising teacher to keep up-to-date with developments in science education, both in curriculum developments and in research, so as to inform and direct their teaching. We hope that in the future IASEL, and now IAPSE, will be able to assist teachers in making use of science education research, and that more teachers will get involved in research, particularly action-research in their own schools and classrooms and laboratories.

Since 1980 the whole landscape in science education and SER has changed in Ireland, and especially since 2000, and it is encouraging to see the increased interest in STEM education, the increased output of SER, the number of active STEM centres, and the greater international involvement of Irish researchers in conferences and projects.

Appendix 1: Centres for Science Education

CalMast, Waterford Institute of Technology

Centre for the Advancement of Learning of Maths, Science and Technology

www.calmast.ie

CaSTEL, Dublin City University

Centre for the advancement of Science and Technology Education and Learning

<http://castel.ie/>

CERT, Technological University, Dublin

Chemistry Education Research Team

Claire.mcdonnell@tudublin.ie

EPI*STEM (formerly NCE-MSTL), University of Limerick

National Centre for STEM Education

www.epistem.ie

CERP, University of Limerick

Chemistry Education Research and Practice

Peter.childs@ul.ie

Eureka Centre, University College, Cork

Eureka centre for inquiry-based education in science and mathematics

d.kennedy@ucc.ie

STEM-ERC, TCD, School of Education

Science, Technology, Engineering Mathematics:
Education, Research and Communication

NUIG, School of Education

Centre for Pedagogy and Public Engagement
Research, School of Education

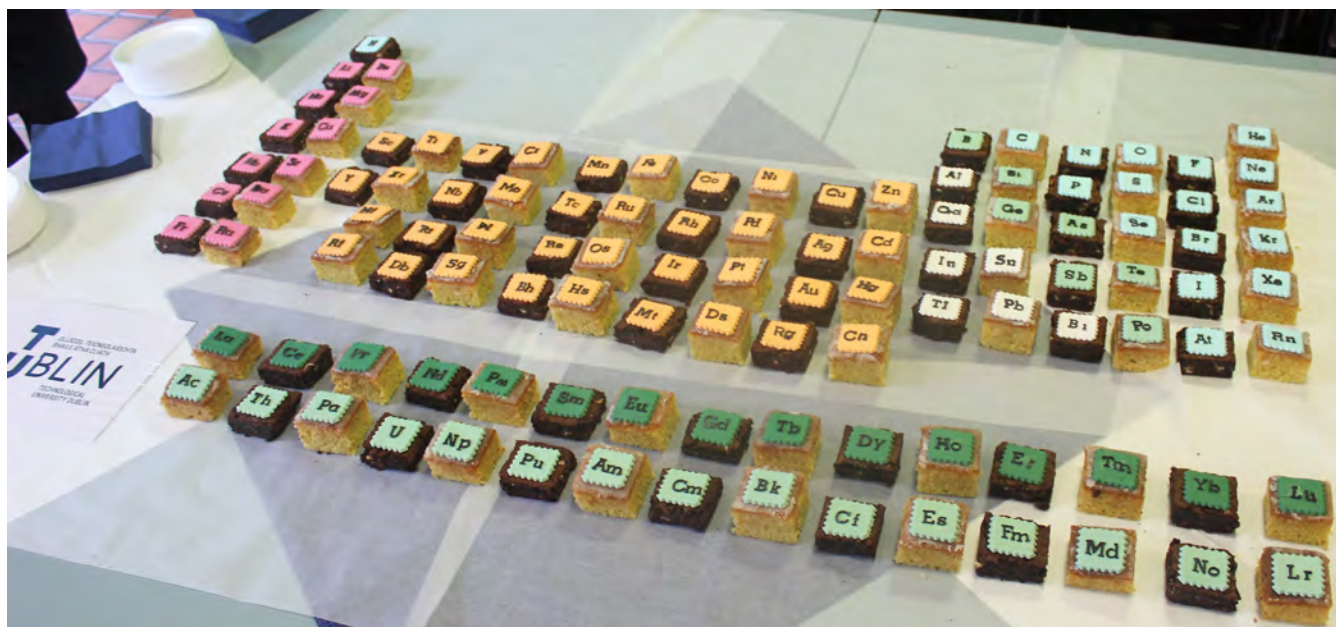
Veronic.mccauley@nuigalway.ie

Biography

Dr Peter Childs came to Ireland in 1978 to teach Chemistry at Thomond College of Education (later amalgamated with the University of Limerick). He started Chemistry in Action! in May 1980 and the ChemEd-Ireland conferences in 1982, both still going strong. He retired in 2009 and has continued to edit Chemistry in Action!, supervise research students, organise Teachers' Workshops and be involved in several European projects and in the EuCheMS Division of Chemical Education.

□

The edible Periodic Table – courtesy of TUDublin



Participants at ChemEd-Ireland 2019 in October 2019 got a chance to eat their favourite element, in the shape of a cupcake. The cakes were baked to mark IYPT at TUDublin and we hope that we will have some of the articles based on talks and workshops at the conference in the next *Chemistry in Action!* Usually the Proceedings are published in the Spring issue, but this year this issue was devoted to celebrating the 40th birthday.

**Don't forget ChemEd-Ireland 2020 is
scheduled in UCC, October 17th.**



The Institute of Chemistry of Ireland: 1980-2020

Margaret Franklin
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Early history

The Institute of Chemistry of Ireland (ICI) is the professional body representing chemists in this country. Its origins go back to the year of the foundation of the Irish Free State, when a meeting of Irish chemists was held on 15th May, 1922. Several further meetings were held over the following year, resulting in the formation of The Chemical Association of Ireland, which was established at a meeting held on 15th June 1923. This had a membership of about 40 chemists and remained active until 1930. Its successor, The Irish Chemical Association, was founded on 14th March 1936 and flourished for the next fourteen years, during which time its membership grew to around 300.

Finally, in 1950, The Institute of Chemistry of Ireland was incorporated as a Company. This placed it on a firm footing as a Professional Body and enabled it to have Government recognition. The original Register of Members lists 136 founder members, all of whom were admitted to membership on 13th March 1950. Over the next three decades, its membership increased and by 1980, The year that *Chemistry in Action!* was first published, it numbered over 500 members.

At the Institute of Chemistry of Ireland Annual General Meeting, in April 1980, Desmond M. Fitzgerald was elected President. The following month, Sligo Regional Technical College hosted the 5th Annual Congress of the Institute. The first three Congresses had all been hosted by University College Dublin and the themes were (1) Pharmaceutical & Fine Chemicals Industry, (2) Chemistry & The Law and (3) Chemistry & the Environment. The 4th Congress, with the Title 'The Chemist in Industry' was hosted by University College Cork. Sligo was the first of the recently established RTCs to host the Annual

Congress. The theme was 'Chemistry in Ireland in the 80s.' It was at that Congress that Peter Childs launched '*Chemistry in Action!*', a publication which was to prove a valuable resource for chemistry teachers and their students and to which The Institute of Chemistry of Ireland was happy to lend its support from the very start.

During the 1980s, Annual Congresses were held alternately at Dublin and provincial venues and were hosted by UCD, UCG and UCC. Some of the congresses were held in hotels (including the Burlington & Montrose hotels in Dublin and the Imperial Hotel in Cork) and the Annual Dinner, held in conjunction with the congress, proved to be a successful social event. Galway was always a popular venue and since the congresses were usually held on Fridays, people often remained in Galway for the weekend. The University of Limerick first hosted a congress in 1990, with the theme 'Chemistry and the Environment', while Athlone RTC became the second of the Regional Technical Colleges to host a congress in 1991, with the theme 'Polymer Chemistry in Ireland'.

The Boyle-Higgins Award

In 1985, Council decided to establish a major award, to recognise an outstanding and internationally recognised research contribution to the advancement of chemistry, by a chemist of any nationality working in Ireland, or by an Irish chemist working overseas. It was a condition of receiving the award that the recipient be a Member of The Institute of Chemistry. The winner would be invited to give a lecture, after which he or she would be presented with a gold medal. The Award was named the Boyle-Higgins award. It could be given for work carried out under one of the following headings: (a) Pure Chemistry (b) Applied and Industrial Chemistry or (c) Chemical Education. However, it was not

until 1990 that the first Boyle-Higgins Gold Medal was awarded. The first winner of this prestigious award was Professor Duncan Thorburn-Burns, who had recently been appointed as Professor of Analytical Chemistry at Queen's University, Belfast. His award was in the category of 'Applied Chemistry' and his lecture was entitled 'Some Instrumental Aspects of Analytical Reagents and Reactions'. The second winner, who was awarded the Boyle Higgins Gold medal two year later, in 1992, was Dr Peter Childs, of the University of Limerick, for his enormous contribution to Chemical Education. In fact, this was the only time the award has been in the Education category. The award has not been given every year, but most of the subsequent awards were for Pure Chemistry, with notable academics such as Prof. Tony Mc Kervey, Prof. David Brown, Professor Dick Butler, Prof. Dervilla Donnelly, Prof. Rory More-O'Ferral, Prof. Albert Pratt, Prof. Sean Corish, Prof. Frank Hegarty, Prof. Pat Guiry and Prof. John Kelly being listed in the roll of honour. Apart from Professor Thorburn-Burns, other recipients in the 'Applied Chemistry' category have included Prof. Malcolm Smyth (Analytical Chemistry), Dr. Sheila Willis (Forensic Science), Prof. Dermot Diamond (Chemical Sensors), Prof. Kieran Hodnett (Pharmaceutical Compounds), Prof. Henry Curran (Fuel Combustion) and Prof. Suresh Pillai (Nanotechnology).

Eva Philbin Public Lecture Series

In 2005, The Institute of Chemistry of Ireland established an Annual Award for Chemistry, which, since 2007, has been named the Eva Philbin Public Lecture Series. The award is for a practising chemist, who has made a significant contribution to the advancement of chemistry and has considerably raised the profile of chemistry and who is also an excellent science communicator. The recipient may be of any nationality and may be employed in industry, academia, or the public service. The winner is presented with a commemorative plaque and is invited to give three public lectures in Ireland, one in Dublin and the other two at provincial venues. One of these lectures is usually given during the month of November, associated with Science Week. The first recipient was Prof. David Leigh, of Edinburgh University, who enthralled his audience with his description of the 'Magic' of Molecular Machines. Other famous names who

received this award have included Prof. A. Prasanna de Silva (QUB), Dr. Mary Archer, Prof. Martyn Poliakoff (Nottingham Univ.), Prof. Lesley Yellowlees (Edinburgh), Prof. Michael Zawarotko (UL) and Prof. John Sodeau (UCC).

In more recent years, an Industrial Chemistry Award has been sponsored by Henkel Ireland. This is open to employees or Principals of the chemical & pharmaceutical industry, fine chemicals & related sectors on the island of Ireland, involving work substantially chemical in nature, that can clearly show support of industrial chemistry functions. So far, there have been just three recipients of this award. In 2015, it was awarded to Dr Donal Coveney of TopChem, in 2016 it went to Dr Imelda Shanahan of TMS Environmental Ltd. and in 2017, it was given to Dr Tom Moody of the Almac group.

School activities

In addition to these awards, The Institute of Chemistry of Ireland gives a medal each year to the student (or students) who achieve the highest marks in the Honours Leaving Certificate examination in Chemistry. On several occasions, two or more students have tied for the top place and all of them were awarded medals. The record has been nine students achieving top marks! The Institute also sponsors the annual Science Week quiz organised by the ISTA for secondary school students and it organises a Schools Poster or Newsletter competition, on a different chemical topic, each year.

Irish Universities' Colloquium

Another major event in the calendar is the annual Irish Universities' Chemistry Research Colloquium, which is held in a different university each year and provides a forum where postgraduate students can present their research. This has been supported by The Institute of Chemistry of Ireland right from the start. The 71st Colloquium was held in Dublin on June 20th & 21st 2019 and was jointly hosted by the Royal College of Surgeons in Ireland (RCSI) and the recently established Technological University of Dublin (formerly the DIT).

Other activities

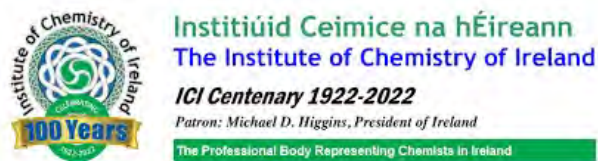
In recent years, the Institute has become one of the sponsors of the Eurachem Analytical Measurement Competition (EAMC). This is a practical laboratory-based competition, where the

participants are asked to conduct a quantitative analysis on a sample by two methods, one a traditional volumetric method, the other a modern instrumental method. They are also asked to identify sources of uncertainty in their measurements and, as far as is practicable, to quantify the uncertainty. It is open to students of laboratory science in any third level institution on the island of Ireland, who have not yet entered the third year of their studies. The aim of the competition is to raise awareness among students, at an early stage in their training, of measurement uncertainty in analytical chemistry and the importance of being able to stand over the validity of their results.

Apart from organising Congresses, supporting the Universities' Chemistry Colloquium and making awards at various levels, the Institute makes the knowledge and expertise of its members available to advise the Government and other agencies on various matters. In 2011, it issued a statement on the need for a hazardous waste treatment facility in Ireland. The EPA has asked the Institute to help raise awareness of the EU regulations on ozone-depleting substances in the environment. The Institute was invited to become a partner in the 'Chemistry is all Around Network', an EU funded project, aimed at stimulating students' interest in the study of Chemistry.

The Institute of Chemistry of Ireland is affiliated with The European Chemical Society (EuCheMS), a federation of professional chemical societies in Europe and sends delegates to the EuCheMS General Assembly each year, as well as participating in the major EuCheMS Congress, which is held in a different European city every two years. The Institute has been successful in its bid to host the 2022 EuCheMS Congress, which will be held in the Convention Centre in Dublin. It is fitting this major Congress should come to Dublin in 2022, marking the centenary of the founding of its precursor, The Chemical Association of Ireland.

<https://keynotepco.ie/wp-content/uploads/2018/10/Notice-of-2022-congress.pdf>



The Institute is entitled to send a delegate to the various EuCheMS divisions and is an active member of several, including the Division of Chemical Education. Dr Peter Childs was chair of the Division for 6 years (2002-2008) and retired in 2019 after 20 years, handing over to Dr Odilla Finlayson (DCU) and Dr Sarah Hayes (UL).

The Institute's journal used to be called *Orbital*, and this became *Irish Chemical News*. Both were published as hard copies and sent to all members, but *Irish Chemical News* is now only published electronically and is available on the Institute website.

The Institute used to have an active Education Committee and in the 1980s held annual teachers' refresher courses, which some of you may remember. These were usually held in January over 2 days and hosted by one of the third level institutions. They were supported financially by the Department of Education and stopped when they withdrew their support. The committee made submissions about new syllabi.

In Ireland ICI is the recognised professional body for chemists but is in competition for professional membership with the Royal Society of Chemistry (RSC), which is very active in the Republic. Physics and Biology are both represented by Irish branches of UK-based organisations: the Institute of Physics and Institute of Biology. The RSC is bigger, wealthier and has many fulltime staff, unlike the Institute, and can thus offer more services to members. The membership of the Institute is much less than it should be because of this competition, especially considering the strength of the chemical industry, and should have several thousand members but in reality it has around 700 at present. Membership is open to teachers and to undergraduates.

The Institute is indebted to the late J. Philip Ryan for writing histories of the early precursors to the Institute:

1. *The Chemical Association of Ireland 1922 – 1936* (1997)
2. *The Irish Chemical Association 1936 – 1950* (2001)

Biography

Margaret Franklin taught at Athlone Institute of Technology for many years until she retired. She is a past-President of the Institute of Chemistry of Ireland.

Editor's note:

I made a point of joining the Institute of Chemistry of Ireland soon after coming to Ireland in 1978 and have been associated with it ever since. My first speaking engagement in Ireland to chemistry teachers was at one of the Teacher's Refresher Courses, invited by Dr Henry Lyons, and I later spoke at several of them. I had the honour to be President of the Institute from 2005-

7, and I was the recipient of the Boyle-Higgins Gold Medal in 1992. As chemists and chemistry teachers we should support the Institute of Chemistry of Ireland as our national professional body for chemists. If every qualified chemist and chemistry teacher were to join the Institute, whose annual fees are quite modest, it would multiply its membership many-fold.

The Evolution of Science Education in the Irish Primary Curriculum

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Introduction

Science, Technology, Engineering and Mathematics (STEM) education has received increased attention in Ireland in recent years, perhaps more so than science education. The STEM Education Review Group (2016) provided an analysis of and recommendations for STEM Education provision at primary and post-primary schools. The *STEM Education Policy Statement 2017-2026* (DES, 2017) that followed, advocates that '*all early years settings and schools will be supported to establish relationships ... with research organisations, further and higher-level institutions.... all early years settings and schools will foster a culture of collaboration for professional learning in STEM education*' (DES, 2017, p. 13). There is much evidence that the Irish public value science and the place of science education in our school system. Science is highly valued for its role in advancing society across a range of functions (SFI, 2015), and more specifically, 82% of parents indicate that they would like to see more of a focus on science in primary schools (Pfizer, 2019).

In the current Irish Primary School Curriculum (DES, 1999a), science is positioned within the curricular area Social, Environmental and Scientific Education (SESE), along with History and Geography. Technology and Engineering are not curricular areas at primary level education. The most recent draft curriculum (still open for consultation) at primary level has proposed five

broad curricular areas, one of these new curricular areas being Mathematics, Science & Technology Education (NCCA, 2020).

This article reports on the evolution of science education in primary classrooms in Ireland, teachers' experiences of primary science and the proposed changes that are outlined for the future.

How did we get to here?

Pre 1922

In 1897, the Board of National Education established the Commission on Manual and Practical Instruction (CMPI) to report on the Educational system in Primary Schools. Their report formed the basis for the *Revised Programme* (1900) (Walsh, 2018). This *Revised Programme* (1900) introduced elementary science amongst other obligatory subjects in the primary school (Commissioners of National Education in Ireland (CNEI), 1902). William Mayhowe Heller, a Senior Science Inspector, had a major influence on the development of science education in Ireland. He was influential in the development of this earliest primary science syllabus. Heller was influenced by Henry Armstrong's passion for science teaching. Elementary Science was largely based on Heller's work on science curricula in London at the time (Childs, 2019). This programme advocated education based on the local environment. However, elementary science (along with some other practical subjects) was not always implemented due to the necessity of

specialist equipment, facilities and training (CNEI, 1905). The subsequent primary school programme introduced in 1922, had a more restricted number of subjects, not including science.

1971

The Primary School Curriculum (1971) was a radical departure from the practice of the previous 50 years. While much focus remained on the core subjects (Irish, English, Mathematics and Religion), it also included Social and Environmental Studies. The Environmental

Studies of this curriculum encompassed Geography and Elementary Science. The preface specified that *‘the aim should be, not to convey the maximum amount of factual information, but to arouse and stimulate the child’s interest in his environment, to enable him to understand the various aspects of his experience and to cultivate in him an enquiring attitude of mind’* (Department of Education, 1971, p.12). The sections and content of the syllabus changed from infants to senior classes, as outlined in Table 1.

Table 1: Overview of Environmental Studies syllabus (Department of Education, 1971)

Environmental Studies				
Class Group	Infants	First & Second	Third & Fourth	Fifth & Sixth
Overview of Syllabus content	1. Human Environment 2. Animal Life 3. Plant Life. 4. Nature Walks 5. Language Development & Recording.	1. Human Environment 2. Animal Life 3. Plant Life. 4. Nature Walks 5. Natural Phenomena 6. Language Development & Recording.	1. Human Environment 2. Animal Life 3. Plant Life. 4. Nature Expeditions 5. Investigation Table 6. Natural Phenomena 7. Language Development & Recording	1. Human Environment 2. Animal Life 3. Plant Life. 4. Nature Expeditions & Natural Phenomena 5. Elementary Science 6. Language Development & Recording

It is note-worthy that ‘Elementary Science’ only appears on the syllabus for fifth & sixth class. Topics in Elementary Science included: Air, Water, Heat, Sound and Light, Gravity and Levers and simple experimental study (e.g. of a bicycle pump, vacuum cleaner, flashlight battery). The Natural Phenomena section at third and fourth class included Space, Water, Heat & Cold, Thermometer, Rain and Wind. These were to be further developed in fifth and sixth class. A huge part of the 1971 Environmental Studies involved ‘nature study’, which focused on animal and plant life, nature walks and expeditions.

1999

The Primary Curriculum published in 1999 included 23 full-colour handbooks. This comprises two booklets for each of the 11 subjects (one documenting the curriculum content and the other providing teacher guidelines) and the

Introduction. The *Primary Science Teacher Guidelines* (DES, 1999c) outlines the nature of science, science in a child-centred curriculum, constructivist approaches to teaching science, as well as a focus on skill development. It also provides curricular and organisational planning guidelines for teachers, indicating possible integration with other curricular areas and suggested methodologies to maximize pupil participation and learning.

The inclusion of Science (within SESE) in the *Primary School Curriculum* (1999) brought a major change to the curriculum of primary schools and reflected the importance that science and technology have in many aspects of our daily lives, at work, at school and at home. This eight-year Science curriculum was introduced from junior infants to sixth class, with a minimum weekly allocation of time (45 minutes for infant classes, and an hour per week for older classes).

The same four strand units were taught and developed from infants through to sixth class: Living Things, Materials, Energy & Forces and Environmental Awareness and Care. These strands and strand units are outlined in Table 2. The only changes in strand units across class

groups are in the Environmental Awareness and Care strand and the Living Things strand. The *Primary Science Curriculum* (DES, 1999b) details the learning objectives and skill development for each class level.

Table 2: Overview of Primary Science Curriculum (DES, 1999b)

Primary Science				
Class Group	Infants	First & Second	Third & Fourth	Fifth & Sixth
<u>Strands</u>	Living Things	Living Things	Living Things	Living Things
Strand Units	• Myself • Plants and animals	• Myself • Plants and animals	• Human Life • Plants and animals	• Human Life • Plants and animals
	Energy & Forces	Energy & Forces	Energy & Forces	Energy & Forces
	• Light • Sound • Heat • Magnetism and electricity Forces	• Light • Sound • Heat • Magnetism and electricity Forces	• Light • Sound • Heat • Magnetism and electricity Forces	• Light • Sound • Heat • Magnetism and electricity Forces
	Materials	Materials	Materials	Materials
	• Properties and characteristics of materials • Materials and change	• Properties and characteristics of materials • Materials and change	• Properties and characteristics of materials • Materials and change	• Properties and characteristics of materials • Materials and change
	Environmental Awareness and Care	Environmental Awareness and Care	Environmental Awareness and Care	Environmental Awareness and Care
	• Caring for my locality	• Caring for my locality	• Environmental awareness • Science and the environment • Caring for the environment	• Environmental awareness • Science and the environment • Caring for the environment

2020

A notable change from the current *Primary School Curriculum* (DES, 1999a) in the proposed Draft Primary Curriculum Framework-for consultation (NCCA, 2020) is the changing position of science. Science was positioned within the curricular area of Social, Environmental and Scientific Education (DES, 1999b), but the proposed draft positions Science with Mathematics and Technology, in a new curricular area 'Mathematics, Science and Technology Education'. The draft framework (NCCA, 2020) described the new curricular area as follows (p.13):

Mathematics, Science and Technology Education supports children's capacity to understand and engage fully with the world around them. Mathematics provides the foundation for science and technology and is the study of the relationships, connections and patterns that surround us. The overarching aim of mathematics is the development of mathematical proficiency.

Fig

Science and technology are intrinsically linked and enable children to benefit from learning about, and working with traditional, contemporary and emerging technologies. Using technologies children will experience opportunities to generate new ideas or solutions as part of a design process and through playful experimentation and investigation. They also enable children to develop an interest in and understanding of the biological, material and physical world by exploring and investigating scientific concepts and processes.

Figure 1 provides an illustrative summary of the timeline of evolving changes in the provision and place of science education in our primary school system.

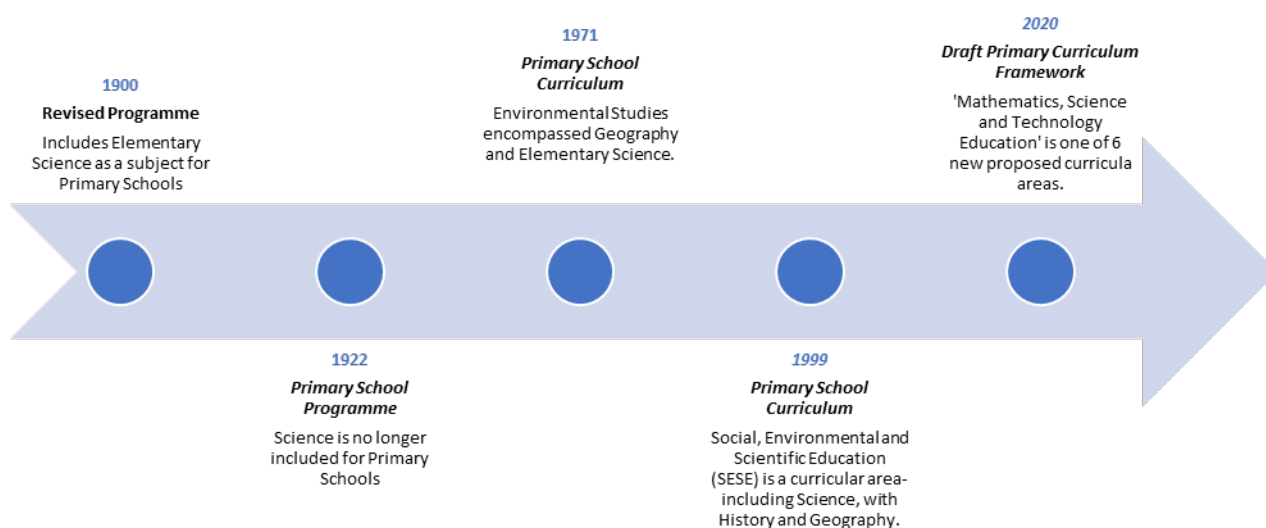


Figure 1. Timeline of evolving position of Science in Irish Primary Education

Implementation of the Primary Science Curriculum (1999)

The Inspectorate's Report (DES, 2012) of *Science in the Primary School 2008* identified some findings of good practice in schools, as well as concerns and recommendations for future

development. Findings of good practice included effective whole-school planning, involving collaboration between teachers and involvement in projects linking local industries. The majority of teachers demonstrated good understanding of concepts. The Materials and Environmental awareness & care strands were the strands where

pupil achievement was best. Some concerns were identified about pupils' understanding of Plant and animal life. The traditional 'nature study' approach (in the 1971 curriculum) does not encompass the learning objectives of the Living Things strand (in the 1999 curriculum). Planning for the development of the Working Scientifically skills, and Design & Make were often neglected. The Inspectorate's (DES, 2012) key recommendations specified that Science lessons should not be based on any particular text-book, and teachers should be familiar with the Working scientifically and Designing and making objectives for their class level, and implement programmes that enable their pupils to achieve these objectives.

Teachers' & Pupils' Experience of Primary Science

The National Council for Curriculum and Assessment (NCCA) commissioned research to examine the implementation of the *Primary Science Curriculum* (1999). This research was published in a two-phase report (Varley, Murphy & Veale, 2008a, 2008b). Primary children are enthusiastic about primary school science (Varley *et al.*, 2008a). The majority of pupils are well-disposed towards learning about virtually all of the content areas outlined in the Primary Science Curriculum (Varley *et al.*, 2008a). The report found that although child-centred pedagogies are emphasised in the primary science curriculum preface (DES, 1999b), child-led investigations appeared to be used infrequently in some cases. Hence, in some cases, the overuse of teacher demonstration and explanation limited the depth and complexity of pupils' skill development. The report (Varley *et al.*, 2008a) also found that children's reports of lessons relating to the strand of Environmental awareness and care were infrequent in comparison with the other three strands.

First year post-primary students indicated a preference for post-primary science over their experiences of primary science (Varley *et al.*, 2008b). For many, this was related to greater exposure to post-primary science in comparison to primary science, and in particular, having regular opportunities to conduct experiments at post-primary level. Preparation for post-primary entrance examinations in subjects other than science appeared to have dominated sixth class

experiences for a number of students (Varley *et al.*, 2008b), and so limited the challenges and more meaningful learning opportunities in primary science.

While much literature has reported primary teachers' lack of confidence in teaching science (Holroyd & Harlen, 1996), improvements have also been noted (Murphy, Neil & Beggs, 2007). The need to substantially increase science professional development for primary teachers was identified over a decade ago (Murphy *et al.*, 2007). Professional development in science for primary teachers has been effective and those who have engaged in it have noted increased self-efficacy (Murphy *et al.*, 2007; Nadelson *et al.*, 2013).

Primary Science in Initial Teacher Education

In a study of 373 first year B.Ed. students (O'Dwyer & Hamilton, 2017), it was found that the study of junior certificate science (91.8%), leaving certificate physics (6.7%), chemistry (13.7%) and biology (76.7%) was representative of the national uptake of science subjects at second level. B.Ed. students' limited prior experience of the physical sciences does contribute to their lack of self-efficacy in teaching primary science.

Research in Ireland (Murphy & Smith, 2012) and the UK (Harlen, 1997; Murphy *et al.*, 2007) has found that although some pre-service primary teachers are positive about teaching science, insufficient Subject Matter Knowledge (SMK) is still a concern. Many are also apprehensive about teaching methodologies and classroom management issues in teaching science (Murphy & Smith, 2012). In addition to the complexity of balancing SMK and Pedagogical Content Knowledge (PCK), Cremin *et. Al.* (2015) outlined many synergistic features of teaching primary science: play and exploration, motivation and affect, dialogue and collaboration, problem-solving and agency, questioning and curiosity, reflection and reasoning, and teacher scaffolding and involvement. Teachers with low SMK and low confidence employ various strategies for coping, some of which when regularly applied have a severely limiting effect on children's learning (Harlen & Holroyd, 1997). Many beginning primary school teachers use classroom and teaching activities that work, as a source of

PCK in science. They rely on repeating science activities that have worked in the past. Although they may still be unsure of the SMK, this is an improvement from avoidance of teaching science.

The aim of science pedagogy cannot be to enable teachers to know the answers to all the questions children may ask (Harlen, 1997). This would be impossible and inadvisable as children would not understand the answer. Harlen (1997) emphasised that teachers need pedagogical strategies for handling children's questions for appropriate investigative learning. It is important to note, that while development of SMK can contribute to pre-service teachers' confidence in teaching, this content knowledge must be appropriately balanced with specific science pedagogical approaches. The challenge as teacher educators is to coalesce the students' needs and address their concerns. Varley *et al.* (2008) recommended that teacher education colleges provide in-depth science education courses as an option in the Bachelor of Education (B.Ed) degree. Such specialist Science Education modules are now available as 'elective' modules for B.Ed. students in their third and fourth years of study.

In addition, the *Irish Association for Primary Science Education (IAPSE)* was launched in November 2019 to promote the teaching and learning of science in primary schools throughout the island of Ireland. The association aims to ensure that primary science education will support our young people in developing the requisite, scientific knowledge, skills, attitudes and values to make sense of the world in which they live.

Where to from here?

Curriculum decisions are influenced by a multiplicity of factors (Walsh, 2018), including historical, ideological, cultural, political, economic, theoretical and practical considerations (Livingston, Hayward, Higgins & Wyse, 2015). In recent years, science and STEM curricula have been influenced by political and economic considerations. Nationally, many primary science curricula and frameworks reference the importance of a STEM literate society as well as provision of a STEM workforce (e.g. National Science Board (2007) in the US, Royal Academy of Engineering (2016) in the UK, Commonwealth of Australia (2015) in Australia and DES (2017) in Ireland). Therefore, it is not surprising that science has been re-positioned in the proposed changes at primary level in Ireland (NCCA, 2020). It has been removed from SESE, and

situated with other STEM disciplines - Mathematics and Technology.

There has been an effort since the Lisbon Strategy (European Council, 2000) to promote a competence-based curriculum and learning outcomes model within Europe, which integrates knowledge, skills and attitudes and attempts to transcend subject learning (Walsh, 2016). This is evident in recent curricular changes at second level e.g. *Framework for Junior Cycle 2015* (DES, 2015). It is also evident that curricula are influenced by economic arguments and there is a strong emphasis on accountability (Priestley & Biesta, 2013). Biesta and Priestley (2013) argue for a greater focus on the holistic development of the learner, rather than a focus on what they should learn.

Priestley and Biesta (2013) and Walsh (2018) outlined three trends in modern day curriculum development: a return to constructivist and child-centred approaches, an emphasis on the teacher as a central agent in curriculum development, and the formulation of curricula in terms of competences and capacities. The following extracts illustrate the focus on child-centred and constructivist learning in previous Irish primary science curricula:

Social & Environmental Studies: Aims & Approach (Department of Education, 1971)

"The child has a natural urge to explore and investigate his own environment and thus it is good educational practice to direct and channel this curiosity so as to enable him to differentiate his experiences, to organise his knowledge and to form a satisfactory concept of his environment" (p.11)

Primary Science Teacher Guidelines (DES, 1999c)

"The constructivist view of learning involves beginning from children's ideas and practical experiences, reflecting on where children are in the progression towards the development of more scientific ideas, providing opportunities for children's ideas to be tested and assessing the extent of any change in ideas and in the skills of working scientifically" (p.3)

Walsh (2018) outlines the following as key in reviewing the current Primary School Curriculum

in Ireland: less is more; clarity of purpose, aims and principles; curriculum development and alignment; theoretical underpinning and teacher professionalism. It will be important that the NCCA consider these in their consultation, development and implementation of the proposed new framework. In the current curricular changes at primary and post-primary levels, the National Council for Curriculum and Assessment (NCCA) include efforts to involve teachers as innovators rather than implementers of curriculum (Looney, 2014). As teachers and educators embark on the consultative phase of the proposed *Draft Curriculum Framework* (NCAA, 2020), it is important that the NCCA are clear on the nature of the curriculum, i.e. to specify whether it is a prescribed curriculum or a framework that can be modified at a school or individual teacher level (Walsh, 2018). It is important that written documentation is clear (Walsh, 2018) as it is key to communicating the curriculum to teachers (Castro Superfine, Marshall & Kelso, 2015).

Varley *et al.* (2008a) recommended that initial teacher education institutions provide specialist courses in science education for pre-service primary teachers, to develop primary science 'specialists'. It was proposed that such subject specialists within primary education would build capacity and expertise in the primary sector in the longer term. Four years later, the Inspectorate's report of Science in the Primary School (DES, 2012) also recommended 'designating a teacher to provide effective curriculum leadership in science at school level can have a very beneficial effect on the quality of school planning and curriculum implementation in the subject. Schools should consider designating a teacher as a Science coordinator for this purpose' (p.44). Four more years later, the STEM Education Review Group also recommended the development of 'STEM Champions' in primary schools, professional development opportunities for primary teachers to expand their knowledge in STEM subjects and extensive curricular materials for primary teachers that operationalise learning outcomes in STEM subjects (STEM Education Review Group, 2016).

It is evident that there is a need to continue to support professional development of primary teachers in their teaching of science. There are many examples of professional development in science for primary teachers in Ireland. These

include opportunities provided by Science Foundation Ireland (SFI) initiatives such as *Discovery Primary Science and Mathematics* (DPSM) award (SFI, 2020a, 2020b) and the RDS Science Blast STEM learning CPD programme (RDS, 2020), as well as courses offered by Education and Training Boards in 19 centres across the county, and by the Professional Development Service for Teachers (PDST) from their Primary STEM Team (PDST, 2020).

References

- Biesta, G. and Priestley, M. (2013). Capacities and the Curriculum (in) Priestley, M. and Biesta, G. (2013) (Eds.). *Reinventing the Curriculum: New Trends in Curriculum, Policy and Practice*. London: Bloomsbury, pp. 35-49.
- Castro Superfine, A., Marshall, A. and Kelso, C. (2015). Fidelity of Implementation: Bringing Written Curriculum Materials into the Equation. *The Curriculum Journal*, 26:1, pp. 164-191.
- Childs, P. (2019). Pioneers of Science Education #8 William Mayhowe Heller, *Science*. 55 (1), 42-48.
- Commissioners of National Education in Ireland (CNEI). 1902. *67th Report of the Commissioners of National Education in Ireland for 1900*, Appendix, Section II (F). Dublin: Alexander Thom.
- Commissioners of National Education in Ireland (CNEI). 1905. *71st Report of the Commissioners of National Education in Ireland for 1904*. Dublin: Alexander Thom.
- Commonwealth of Australia (2015). *National Innovation and Science Agenda*. Available online: https://www.industry.gov.au/sites/default/files/July%202018/document/pdf/national-innovation-and-science-agenda-report.pdf?acsf_files_redirect
- Cremin, T., Glauert, E., Craft, A., Compton, A. & Stylianidou, F. (2015) Creative Little Scientists: exploring pedagogical synergies between inquiry-based and creative approaches in Early Years science, *Education* 3-13, 43(4), 404-419.
- Department of Education and Skills, DES (2017), STEM Education Policy Statement 2017–2026, available online: <https://www.education.ie/en/The-Education-System/STEM-Education-Policy/stem-education-policy-statement-2017-2026-.pdf>

Department of Education and Skills, DES (2015). *Framework for Junior Cycle 2015*. Available online:

<https://www.education.ie/en/Publications/Policy-Reports/Framework-for-Junior-Cycle-2015.pdf>

Department of Education (1971). *Primary School Curriculum: Teacher's Handbook –Part 1 and 2*. Dublin: Department of Education.

Department of Education and Science, DES (1999a), *Primary School Curriculum: Introduction*, available online:

<https://www.curriculumonline.ie/getmedia/93de2707-f25e-4bee-9035-92b00613492e/Introduction-to-primary-curriculum.pdf>

Department of Education and Science, DES (1999b), *Science: Social, Environmental and Scientific Education Curriculum*, available online:

https://www.curriculumonline.ie/getmedia/346522bd-f9f6-49ce-9676-49b59fdb5505/PSEC03c_Science_Curriculum.pdf

Department of Education and Science, DES (1999c), *Science: Social, Environmental and Scientific Education Curriculum: Teacher Guidelines*, available online:

https://www.curriculumonline.ie/getmedia/8aff1e2-e969-4f64-af35-937da5b0ad18/PSEC03c_Science_Guidelines.pdf

Department of Education and Skills (DES), (2012). *Science in the Primary School 2008: Inspectorate Evaluation Studies*. available online: <https://assets.gov.ie/25306/c0e9699507af414996fa59f38ac22d2a.pdf>

European Council. 2000. *The Lisbon Strategy for Growth and Jobs*. Brussels: European Council. http://cordis.europa.eu/programme/rcn/843_en.htm.

Harlen, W. (1997). Primary Teachers' Understanding in Science and its Impact in the Classroom. *Research in Science Education*, 17(3), 323-337.

Harlen, W. & Holroyd, C. (1997). Primary teachers' understanding of concepts of science: impact on confidence and teaching. *International Journal of Science Education*. 19(1), 93-105.

Holroyd, C. & Harlen, W. (1996) Primary teachers' confidence about teaching science and technology, *Research Papers in Education*, 11(3), 323-335.

Livingston, K., Hayward, L., Higgins, S. and Wyse, D. (2015). Multiple Influences on Curriculum Decisions in a Supercomplex World. *The Curriculum Journal*, 26:4, pp. 515-517.

Looney, A. 2014. Curriculum Politics and Practice: From 'Implementation' to 'Agency'. *Irish Teachers' Journal* 2 (1), 7–14.

Murphy, C. Neil, P., & Beggs, J. (2007) Primary science teacher confidence revisited: ten years on, *Educational Research*, 49:4, 415-430, DOI: [10.1080/00131880701717289](https://doi.org/10.1080/00131880701717289)

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.

Nadelson, L. S., Callahan, J., Pyke, P., Hay, A., Dance, M., & Pfister, J. (2013). Teacher STEM perception and preparation: inquiry-based STEM professional development for elementary teachers. *The Journal of Educational Research*, 106 (2), 157–168.

<https://doi.org/10.1080/00220671.2012.667014>.

National Council for Curriculum and Assessment (NCCA) (2020), *Draft Primary Curriculum Framework*, available online:

<https://ncca.ie/media/4456/ncca-primary-curriculum-framework-2020.pdf>

National Science Board. (2007). A national action plan for addressing the critical needs of the U.S. science, technology, engineering, and mathematics education system. Washington, D. C: National Science Foundation

O' Dwyer, A. & Hamilton, M. (2017). "A Lot of time was wasted on inquiry and Investigations" The challenge of supporting a diverse cohort of pre-service primary science teachers, Oral Presentation In. *European Science Education Research Association*, International Conference. Dublin, Ireland: 21-25 August.

Pfizer (2019). Health & Science Index 2019 Quantitative Research. Available online: https://www.pfizer.ie/sites/default/files/pfizer_health_and_science_index_deck_for_attendees.pdf

Priestley, M. and Biesta, G. (2013) (Eds.). *Reinventing the Curriculum: New Trends in Curriculum, Policy and Practice*. London: Bloomsbury.

Professional Development Service for Teachers (PDST) (2020). Primary STEM Team, available online: <https://pdst.ie/PrimarySTEM>

PSSP, (1994), *Primary Science Starts Here*, Limerick: Mary Immaculate College

Royal Academy of Engineering (2016). The UK STEM Education Landscape: A report for the Lloyd's Register Foundation from the Royal

Academy of Engineering Education and Skills Committee. Available online:
www.raeng.org.uk/stemlandscape, ISBN: 978-1-909327-25-2

Royal Dublin Society (RDS) (2020). *Science and Technology: RDS STEM learning*, available at:
<https://www.rds.ie/stem>

Science Foundation Ireland (SFI) (2020a), *SFI Discover Primary Science & Maths Award*, available online:
<https://www.sfi.ie/engagement/discover-primary-science-and-maths/award/index.xml>

Science Foundation Ireland (SFI) (2020b). *DPSM/ESERO Continuous Professional Development*, available at:
<https://www.sfi.ie/engagement/discover-primary-science-and-maths/cpd/>

STEM Education Review Group (2016), *A Report on Science, Technology, Engineering and Mathematics (STEM) Education*, available online:
<https://www.education.ie/en/Publications/Education-Reports/STEM-Education-in-the-Irish-School-System.pdf>

Varley, J., Murphy, C. & Veale, O. (2008a). *Science in Primary Schools, Phase 1*. Research commissioned by the National Council for Curriculum and Assessment (NCCA). May 2008. available online:
https://ncca.ie/media/2413/science_in_primary_schools-phase_1.pdf

Varley, J., Murphy, C. & Veale, O. (2008b). *Science in Primary Schools, Phase 1*. Research commissioned by the National Council for Curriculum and Assessment (NCCA). June 2008. Available online:
https://ncca.ie/media/1501/science_in_primary_schools_phase2_rr11.pdf

Walsh, T. (2016): 100 years of primary curriculum development and implementation in Ireland: a tale of a swinging pendulum, *Irish Educational Studies*,
DOI:10.1080/03323315.2016.1147975

Walsh, T. (2018). *Towards an Overview for the Redeveloped Primary School Curriculum: Learning from the past, learning from others*.

Available online:
https://ncca.ie/media/3459/seminar_one_walsh_paper.pdf

Biography

Dr Anne O' Dwyer lectures Primary Science Education in Mary Immaculate College. She is a member of the Department of STEM Education. She teaches Science to pre-service primary teachers, and is involved with coordination and teaching on the M.A. in STEM Education, working with in-service primary teachers. Her doctoral research investigated learners' difficulty in Organic Chemistry. Her current research interests are focused on facilitating teachers' and pupils' learning in Science and STEM education.

Dr Miriam Hamilton is a lecturer in education in Mary Immaculate College, Limerick, Ireland and a member of the Department of STEM Education. Having spent much of her career teaching at second level, she transitioned in recent years to teacher education, where she teaches science education to undergraduate and postgraduate pre-service teachers. Her research studies and publications span a variety of educational domains including: the social context of education, student experience, cultural pedagogy and reflective self-study inquiry.

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Editor's note

One of the first formal developments in primary science was the Primary School Science Project (PSSP), a joint venture of Mary Immaculate College, Thomond College of Education and the Limerick Teacher's Centre. The joint directors were Peadar Cremin (MIC) and Dr Peter Childs (TCE). It ran from 1987 to 1994, involving a series of workshops for local primary teachers, culminating in the publication of the book *Primary Science Starts Here*, (PSSP, 1994). The experience and ideas from this project fed into the review of the Primary School Curriculum and the science content and approach in the new curriculum.

On hundred years (almost) of Leaving Certificate Chemistry

Randal Henly

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Mount Temple School 1962-1998

To mark the publication of 40 years of Chemistry in Action!, Peter Childs asked me to write about the changing pattern of the chemistry syllabus and exam papers over that period. However, to see the full pattern, I have decided to go further back, to what went before 1980.

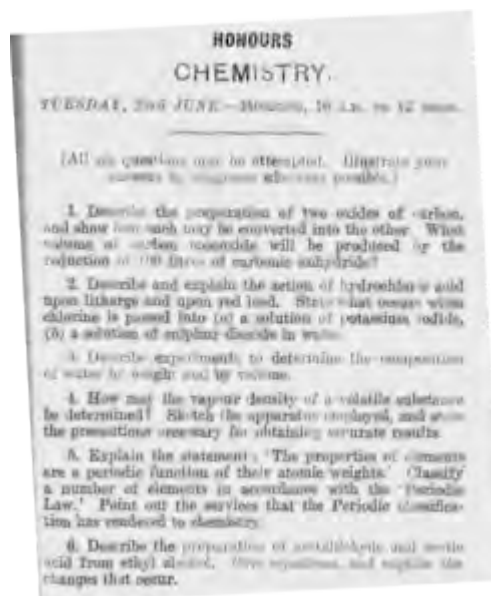
The earliest exam paper in (honours) chemistry that I have been able to access is that of 1925. There are six questions on it, all of which had to be attempted.

In 1930, the syllabus was similar, but in the exam, there were ten questions, six of which had to be answered. In 1940, the syllabus was apparently still the same but then the examinees had a choice of any six questions out of twelve.

Questions on the exam paper were mainly on inorganic chemistry and gravimetric analysis. A couple of concepts examined will be alien to any teachers under the age of about sixty, but I imagine teachers of my own vintage should be able to recall them: gram equivalents (1), green vitriol (2), oxyacids of phosphorus (3). (See footnote for explanation of these terms.)

Moving on another ten years to 1950, it appears that there had been some additions to the syllabus. Mentioned on the exam paper of that year are Dulong and Petit's law, decinormal solutions (4), Avogadro's Law, ions, permanganate and oxalic acid titrations, beet sugar and glucose, and soap manufacture.

Atomic structure seems to have been discovered by the exam setters during the following decade, for on the papers of the last few years of the fifties there are parts of questions about electrons, protons, atomic number and the structures of sodium and chlorine.



The emphasis of that syllabus was still on inorganic chemistry and analysis. The topics asked on the 1963 exam paper were:

- Q.1 Preparation and properties of chlorine
- Q.2 Preparation and properties of sulphur dioxide and hydrogen sulphide
- Q.3 Manufacture of nitric acid
- Q.4 Calculation of chemical equivalent and atomic 'weight', involving normal solutions, specific heats (Dulong & Petit)
- Q.5 Chemistry of iron or tin; distinguish between ferrous and ferric ions (i.e., Fe^{2+} and Fe^{3+})
- Q.6 Distinguish between lead and calcium salts, and between carbonates and nitrates
- Q.7 Avogadro, vapour density, molecular 'weight', gravimetric analysis calculation
- Q.8 Organic: homologous series, unsaturated compounds, substitution reactions, saponification, fermentation
- Q.9 Organic compounds: ethylene, ethyl alcohol, acetaldehyde (in modern terminology these compounds are called ethene, ethanol, ethanal)

Q.10 Structure of atoms of sodium, magnesium, aluminium, chlorine, argon.

In 1962, I became chemistry master (as teachers were then known) in Mountjoy School Dublin (subsequently to become Mount Temple School in 1972), and my first fifth-form class were the cohorts for the examination of a new chemistry syllabus in June 1964. I never really got to know the previous syllabus; it is only now as I am researching material for this article that I am learning about it. The 'modern' items that had been introduced on that 1962 syllabus included topics like thermo-chemistry, structure of atoms, orbitals, ionisation potentials, shapes of molecules, osmotic pressure and its use in measuring molecular 'weights'.

In the first exam of that syllabus (1964), the paper offered a choice of six questions out of ten, but in reality it was six questions out of sixteen, for there were six questions that consisted of an 'either' and an 'or' choice. The topics on that paper were:

- Q. 1 Covalent and other bond types.
- Q. 1 Preparation and properties of ammonia.
- Q. 2 Shapes of molecules, hybridised orbitals.
- Q. 2 Avogadro's hypothesis, Dulong & Petit's law, Graham's law of diffusion.
- Q. 3 Energy levels, atomic configuration.
- Q. 4 Law of mass action, hydrolysis.
- Q. 4 Chemistry of magnesium and calcium.
- Q. 5 Structure of organic compounds acetone, aniline, diethyl ether, formic acid, glycerol, chloroform; preparation and properties of two of these.
- Q. 6 Reaction mechanisms: Cl_2 and H_2 ; Cl and CH_4 ; Br_2 and C_2H_2 ; NaOH and $\text{C}_2\text{H}_5\text{Br}$.
- Q. 6 Determine equivalent weights of metals.
- Q. 7 Polymerisation and isomerism; redox as electron transfer.
- Q. 8 Distinguish between FeSO_4 and FeCl_3 ; KMnO_4 and a Fe^{2+} titration.
- Q. 9 Identify an organic compound from gravimetric data and vapour density.
- Q. 9 Measure vapour density by Victor Meyer method; identify an organic compound from vapour density and gravimetric composition.
- Q. 10 Preparation and properties of halogens and halogen hydrides.
- Q. 10 Compare the chemistry of

phosphorus and nitrogen; explain why several phosphorus acids exist.

Some of the chapter headings of a 1978 textbook summarise what was on the then syllabus:

- Atomic structure
- Bonding valency & formulae
- Shapes of molecules
- Gases, masses and moles
- Stoichiometry
- Acids, bases & salts
- Oxidation, reduction & electrochemistry
- Volumetric analysis I (acids & alkalis)
- Volumetric analysis II (redox & silver nitrate)
- Alkali and alkaline earth metals
- Oxides of elements
- Halogens
- Hydrides of elements
- Colligative properties of solutions
- Thermochemistry
- Kinetics & chemical equilibrium
- Ionic equilibria and pH
- Radioactivity
- Aliphatic hydrocarbons
- Alcohols, aldehydes and ketones
- Carboxylic acids and esters
- Amides & amines
- Benzene and benzene derivatives
- Isomerism
- Polymerisation

The next syllabus came in 1983 (examined 1985) and in summary it comprised the following:

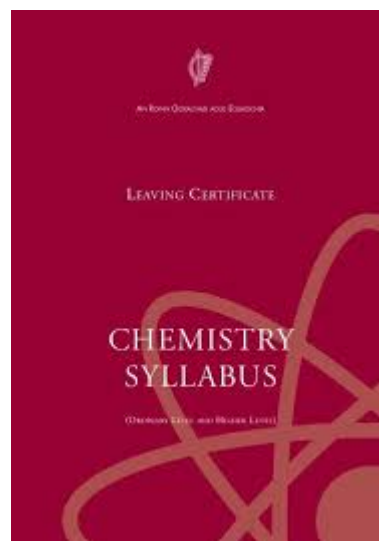
- Atomic structure
- Kinetic nature of matter (diffusion of Br_2 in air, HCl and NH_3 , KMnO_4 in water) Graham's Law, oil film experiment, Brownian movement, smoke cell experiment, law of combining volumes, Avogadro's law, the mole, Dalton's law of partial pressures, $pV = nRT$ calculations, measure relative molecular mass
- Stoichiometry, formulae and equations, empirical and molecular formulae, formula determination, acid-base titrations, standard solutions, Bronsted-Lowry theory
- Periodic table and atomic structure, Periodic Table history, energy levels, flame test, s and p orbital shapes, ionisation energy, electron structure of the first 36 elements, bonding and valency, oxidation states and numbers, redox reactions,

reactions of Group 7 elements and properties of typical chlorides

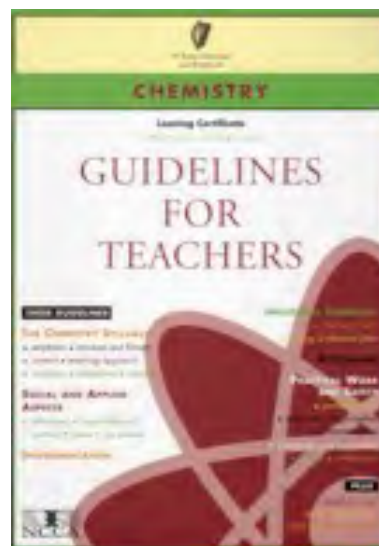
- Thermochemistry, heats of formation, measurement of heats of combustion and of neutralisation, Hess's law, bond energies
- Rates of reaction, effect of temperature, pressure, concentration and of particle size, effect of catalysts, activation energy, catalyst mechanisms
- Crystals and shapes of molecules, electron pair repulsion theory, ionic and molecular crystals
- Carbon and hydrogen, carbon dioxide, carbonates and hydrogencarbonates, hydrocarbons, fractionation, reactions of alkanes, alkenes and alkynes, addition polymers, free radical substitution,
- Chemical equilibrium, reversible reactions and dynamic equilibrium, equilibrium law, Le Chatelier, calculations
- Hydrogen, oxygen and water, properties of oxides, ionisation of water, pH, balancing redox equations, redox titrations, hardness in water and removal, sewage treatment, eutrophication, water analysis
- Nitrogen and sulphur, fertilisers, nitrogen fixation, manufacture of sulphuric acid, atmospheric pollution
- Electrochemistry, electrochemical series, electrolysis, the faraday, Faraday's laws, corrosion and its prevention, fuel cell
- Chemistry of metals, Na, Mg, Ca, Al, occurrence, extraction and uses, iron, copper and zinc
- Organic compounds, primary and secondary alcohols, aldehydes, ketones and carboxylic acids, esters



Up to this time, all syllabuses (for all subjects) were given in an annual publication of the Department of Education, entitled *Rules and Programme for Secondary Schools*.



This changed in 2002, when the Department of Education & Science published a detailed manual about the new 2000 chemistry syllabus, explaining the added social and applied aspects of it, giving details of the added instrumentation section and of the industrial chemistry, and giving helpful guidelines about the industrial chemistry and industrial visits.



Also included is a list of the mandatory experiments that students (5) were to perform. An appendix gave a detailed list of additions to and deletions from the previous syllabus. These are of interest. There were major changes in the syllabus that was introduced in 2000. These are all spelled out in detail in that manual, as listed below. The new curricula are also available online.

https://www.education.ie/en/Schools-Colleges/Information/Curriculum-and-Syllabus/Senior-Cycle-/Syllabuses-and-Guidelines/lc_chemistry_sy.pdf

Deletions

Electron configuration of d-block metal ions. Electrolysis of aqueous copper sulphate, Faraday's laws. Properties of chlorides and oxides. Tests for bromides, iodides and thiosulphate ions. Shapes of molecules with pi bonds. Bromine diffusion, oil film experiment, Brownian movement. Law of combining volumes, Dalton's law, Graham's Law. Formula determination experiment. Permanganate and ethanedioic (oxalate) titrations, back titrations. Isomers of hydrocarbons with more than four carbon atoms. Heat of combustion experiment, calculation of empirical formula from combustion data, bond energy calculations, kilogram calorific value calculations, heat of neutralisation. Distillation of crude oil experiment, cracking experiment, addition reactions of alkynes. Traditional names for organic compounds. Reaction conditions for organic reactions, dehydrogenation of alcohols, chlorination of alcohols, breathalyser, hydrolysis of chloroalkanes, industrial preparations of most organic compounds, mechanism of free radical polymerisation, oxidation of secondary alcohols, acid hydrolysis of esters, use of LiAlH_4 and NaBH_4 as reductants, condensation reactions, Brady's reagent. BiCl_3 experiment, $\text{NO}_2/\text{N}_2\text{O}_4$ experiment. Properties of nitric acid and nitrates, sulphites and sulphuric acid, ammonia in fertiliser experiment, industrial manufacture of sulphuric acid. Polyesters, poly(propenenitrile), fuel cells, effect of heat on metal nitrates, carbonates and hydroxides, reactions of metals with air, water and acids. Extraction, occurrence and uses of calcium, magnesium, copper and zinc.

Additions

Social and applied aspects of many of the topics. Historical development of atomic theory. Electrolysis and displacement reactions of metals. Test for phosphate ion. Distinction between sigma and pi bonding. Boyle's and Charles' laws. Calculations involving an excess of one reactant. Calculation of the effect of dilution on concentration. Volumetric analysis: ethanoic acid in vinegar; iron in an iron tablet, water of crystallisation in a salt; hypochlorite in bleach (however, several of these analyses would have

been done in the past as examples of the applications of volumetric analysis). Greenhouse effect, methane as a contributor, hazards of methane production. Natural gas: composition, addition of mercaptans, petrol and octane numbers. Monitor the rate of catalytic production of oxygen from hydrogen peroxide. Composition of organic compounds; organic syntheses. Instrumental analyses. Pollution of heavy metal ions in water, and their removal. Recycling of plastics and of aluminium. Steel manufacture by electric arc method.

The 2002 exam was the first test of the syllabus of 2000. Eight questions in total had to be answered. Section A was on practical work and two (or three) of the three questions had to be answered. The three topics asked were (Q.1) volumetric analysis of vinegar, (Q.2) preparation of soap, (Q.3) investigation of concentration on rate of reaction.

Section B had eight questions, of which six (or five) had to be answered, as follows:

Q.4 had eleven 'quickies', eight of which had to be answered,

Q.5 was all about ionisation energies,

Q.6 was a series of questions about propene, propanol and propanoic acid,

Q.7 was on some of the 'new' material, gas chromatography and mass spectrometry,

Q.8 was essentially thermochemistry, about methane, butane and 2,2,4-trimethylpentane,

Q.9 was on water, water supplies and sewage treatment,

Q.10 had three parts, two of which had to be answered. These parts were on redox and oxidation numbers, line spectra and energy levels, and Le Chatelier's principle.

Q.11 had three parts, two to be answered: analysis of bleach, radioactivity, industrial production of ammonia, magnesium oxide, nitric acid, aluminium



In 2000 the Department of Education published a 650-page loose-leaf folder entitled '*Chemistry; A Teacher's Reference Handbook*'. This massive tome contains discussions on Teaching Strategies, Gender & Science, Laboratory Organisation, History & Development of Chemistry, and background information of all the topics on the chemistry course.

This background information is contained in ten modules entitled:

1. Atomic structure and trends in the Periodic Table
2. Hydrocarbons
3. Industrial chemistry and case studies
4. Environmental chemistry, water
5. Stoichiometry 1: moles and calculations
6. Alcohols, aldehydes, ketones, carboxylic acids
7. Stoichiometry 2: thermochemistry, kinetics, equilibrium
8. Atmospheric chemistry: oxygen, nitrogen, greenhouse effect, air pollution, ozone layer
9. Materials: polymers, electrochemistry, metals
10. Some Irish contributors to chemistry.

The editors were Declan Kennedy, George Porter and Seán Ó'Donnabháin and the main authors of the material and other contributors to it included Fiona Desmond, Tim Desmond, Brendan Duane, Declan Kennedy, John Toomey, Sheelagh Drudy and Charles Mollan.

The Curriculum and Examinations Board CEB) was set up in 1984 to advise on curriculum and was replaced in 1988 by the National Council for Curriculum and Assessment (NCCA), which became a statutory body in 2001. It has an advisory role to the Minister on curriculum and assessment. Individual subject syllabi are produced by a syllabus or course committee, now called a subject development group, each with a specified membership representing interested bodies. The year 2003 marked the formation of the State Examinations Commission (SEC), a non-departmental public body under the aegis of the Department of Education. It became responsible for the development, assessment and certification of second-level examinations. From then on exam papers were headed State Examinations Commission instead of An Roinn Oideachais.

It was from around that time that pretty little graphics started to appear on exam papers,

making them perhaps more user-friendly. Some are illustrated below.



In 2013, the Department of Education & Science had to issue a letter to schools pointing out that the European Chemicals Agency had designated a number of chemicals, two of which were used in Leaving Certificate Chemistry, as being 'substances of high concern', and banning these chemicals for use in schools. These chemicals were chromium (VI) compounds and cobalt (II) salts.

As a result, four of the mandatory practicals on the course could no longer be set as student experiments. Adjustments were made so that the overall amount of practical work on the syllabus did not change. The preparation of both ethanal and ethanoic acid from ethanol were discontinued, since both of these preparations involve oxidation using a chromium (VI) compound. These were replaced by the preparation of benzoic acid from phenylmethanol (benzyl alcohol) by oxidation with alkaline potassium permanganate solution. The steam distillation of an organic substance was changed to specify the extraction of clove oil, and to include the liquid extraction of eugenol from the emulsion produced, using cyclohexane. In the Le Chatelier's Principle experiments, those that involved chromium (VI) and cobalt (II) compounds were discontinued.

The 2015 exam was on the amended syllabus and Q. 2 on the paper of that year was all about the oxidation of benzyl alcohol to benzoic acid.

A big change for the exam markers happened in 2019, when the traditional large sacks of exam scripts, formerly collected by the markers, became a thing of the past. The exam candidates recorded their answers in answer books that were specially

designed for scanning. All the exam scripts (nearly 9,000 of them in chemistry) were scanned at high speed and in high quality, to be read in due course on-screen, by the examiners. The marking conference that year was a three-day event to standardise the marking (as usual) and to provide training in the new system. The examiners accessed their scripts, by logging on (with a password) to a portal. When marking was complete, the results were submitted to the same portal.

After the results were published, the candidates were able to view their marked scripts on-screen, instead of having to go to their schools as had been the case up to 2018.

Acknowledgements

In researching material for this article, I am very much indebted to George Porter, Declan Kennedy, Fiona Desmond and Judy Purdy (who replaced me as chemistry teacher in Mount Temple).

I also must acknowledge the work done by my past pupil David Malone who has assembled a collection, at both levels, of all the exam papers in maths, chemistry, physics from 1925 to 2019 and the biology papers from 1970 onwards. (Biology as a Leaving Certificate subject was only introduced in 1970.) This collection is available at <http://archive.maths.nuim.ie/staff/dmalone/StateExamPapers/#LC>. David Malone (now a PhD) is presently a senior lecturer at the Hamilton Institute and Department of Mathematics & Statistics at Maynooth University.

The story continues:

Until 2000 it took decades for the LC science syllabi to be revised – nearly 40 years for Biology and Agricultural Science. The course that still has not been revised is Physics and Chemistry, even though a draft syllabus had been prepared and circulated by the NCCA in 2000.

Pressure had mounted from 2006 for more frequent revision of syllabi and new LC science curricula and new draft specifications (as they were called) for Biology, Chemistry and Physics were published in 2011, and interested parties were requested to send in comments. A report on the Consultation was published in 2012.

https://www.ncca.ie/media/2559/science_consultation_report.pdf

Final draft science syllabi were published in 2014. These caused concern amongst teachers as the new specifications were still based solely on a statement of learning outcomes. This led to the ISTA to commission a report from Professor Áine Hyland in 2014 on best international practice in science curriculum development. This came out strongly against a course based only on learning outcomes, with no detail or depth of treatment.



“While the current NCCA draft specifications may be a valid first step in outlining the syllabi, this researcher agrees with the ISTA that it is not sufficient to describe a high-stakes examination programme in terms merely of topics and learning outcomes. 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.” (Hyland, 2014)

The new courses aimed to include 30% assessed practical work through a school-based practical exam. Although was shown to workable in a feasibility study in 2018, the Minister of Education decided in 2019 that there would be no practical assessment due to logistical and financial considerations.

A background document was published for consultation on changes to the LC and subject development groups were charged with producing a revised specification by Sept. 2020, for introduction in 2021.

<https://www.ncca.ie/en/resources/draft-background-paper-and-brief-for-the-review-of-leaving-certificate-physics-chemistry-and-biology-september-2019>

The background document was open for consultation from October to November 2019. A report on the consultation was published in January 2020 and can be accessed below.

https://www.ncca.ie/media/4440/consultation-report-on-bp-for-lc-pcb_20200207.pdf

In the conclusion it says this:

The consultation process revealed many considered concerns, such as the potential for curriculum overload, a lack of specificity in Junior Cycle Science resulting in conflicting interpretations of the curriculum and a feared demotion of propositional knowledge.

Nonetheless, there are many beliefs and practices shared across the spectrum of participants which will support the enactment of the revised curriculum specifications. The overarching views on purpose, core concepts, progression of conceptual understanding, the need for an additional assessment component, a common strand in the form of Nature of Science across all three subjects, and the desire for a clear connected narrative would all be commensurate with the research and ideas in the background paper and will inform the work of the subject development groups.

The consultation findings will inform the deliberations of the development groups as they prepare draft specifications, which will be available for consultation in Q2, 2020.

Consideration will also be given to the identification of supports necessary for successful enactment, in parallel to drafting the curriculum for each subject.”

It remains to be seen whether the Chemistry Development Group (and the other groups) will take on board the concerns of teachers and others to have more than a set of learning outcomes. This was the subject of letters to the Irish Times by Aine Hyland and Peter Childs (3/2/20).

Footnotes:

1. The equivalent weight of an element is the mass of it that combines with or displaces 1.008 g of hydrogen or 8.0 g of oxygen.
2. Green vitriol was the common name of iron (II) (ferrous) sulfate.
3. Hypophosphorous acid, H_3PO_2 , phosphorous acid, H_3PO_3 , orthophosphoric acid, H_3PO_4 , metaphosphoric acid, HPO_3 , pyrophosphoric acid, $\text{H}_4\text{P}_2\text{O}_7$.
4. Before molar solutions came into universal use, concentrations were expressed in terms of ‘normality’. A normal solution was one that contained one gram equivalent of the solute per litre. A decinormal solution thus contained 0.1 gram equivalent per litre.
5. Up to around the 1980s second-level learners were always designated as ‘pupils’, the term ‘students’ being applicable only to third-level learners. From then on, second-level schools had students and the term pupils only applied to those in primary education.

Biography

Randal Henly was Head of Science in Mount Temple School Dublin and taught physics and chemistry there for almost forty years. He has lectured and given demonstrations to science teachers at ISTA meetings, to M.Ed students in UCC and to student teachers in St Patrick’s College, Maynooth. He was a supervisor of student science teachers in UL up to 2018. He has been presenting ‘Fun with Science’ for about twenty years. He is a past Editor of ‘SCIENCE’ and author of several school science textbooks. While not dabbling in science, he is a church organist and choirmaster and a compiler of specialist crossword puzzles.

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Editor's note:

This article only covers LC Chemistry but there have also been changes in science in the junior cycle. In 1980 there was a choice of syllabi: Intermediate Science syllabus A and E (Rural Science), and ISCIIP (a pilot project in IBSE.) These were merged into a new Junior Certificate Science Syllabus in 1989 (examined first in 1992), examined at two levels, Ordinary and Higher. This syllabus was revised in 2003 (Revised Junior Certificate Science Syllabus, first

examined 2006) and for the first time included practical assessment (35%). A new specification, with fewer hours (200 versus 240) and a reduced content, and no specified practical work, was introduced in 2016, first examined in 2019. There have been considerable concerns expressed from teachers about the new course and its implementation. It remains to be seen what effect this will have on enrolments for LC sciences and students' preparedness to study the LC sciences.

Elementary Chemistry

A chemical address

The American chemist Glenn Seaborg (1912-1999) was the only person who could write his address in the symbols of the chemical elements.

He would write his address: **Sg Lr Bk Cf Am**

Sg – Seaborgium, named after him, the first time for a living scientist

Lr – Lawrencium, named after the Lawrence Berkley National Laboratory, where he worked

Bk – Berkelium, named for Berkeley, home of UC Berkeley, his university

Cf – Californium, named after the State where the university is located

Am – Americium, named after America.

(For information on Seaborg's life see https://en.wikipedia.org/wiki/Glenn_T._Seaborg)

Mn Manganism

Manganese miners in the 19th century were found to slur their speech and behave as though they were drunk. They had been exposed to dust containing manganese and had been irreversibly poisoned. They developed psychosis and eventually died. The disease was known as manganism. Some of the symptoms are like those of Parkinson's disease, and are both due to brain damage, but manganese exposure does not cause Parkinson's. Welders are exposed to manganese in the fumes show the symptoms. Manganese is also an essential trace element, so we need it in our diet. But at high concentrations it is a toxin and so the permitted levels in air have been reduced to 5µg/m³. The disease was first described in 1837 by James Couper.

Other diseases associated with the ingestion of heavy metals are plumbism (Pb, lead) and mercurism (Hg, mercury), zincism (Zn, zinc) and cobaltism (Co, cobalt). Many metals like cadmium, nickel, copper and even iron can cause poisoning in excess even when small amounts are essential.

Poison is in everything, and no thing is without poison. The dosage makes it either a poison or a remedy.

Paracelsus (1493-1541)

'The Times They Are A changing' -a review of the development of the school science curriculum in Northern Ireland

Roger McCune

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"Science education offers a distinctive medium for fulfilling general education aims. Science, as a recognised area of human experience, provides a broad and deep perspective of the human condition and the World in which we live. However, its value can be diminished if it is viewed in isolation from other areas of experience. An effective science education is one that articulates closely and functionally with other areas of human experience and activity."

'Change in our Future: A Challenge for Science Education' -Association for Science Education (ASE) policy paper-January 1992.

Introduction

The title of this Bob Dylan song, 'The times they are a changing', released in 1995, acts as a summary of the development of the school science curriculum in Northern Ireland over the past thirty years. A pivotal change was the introduction, in the early 1990s, of a statutory curriculum - the Northern Ireland Curriculum. This established a legal framework, across both the primary and post-primary sectors, for the knowledge, understanding and skills that should be taught to 4 to 16-year olds. The aim was to ensure a common entitlement appropriate to the needs, abilities and aspirations of all young people.

The statutory curriculum designated science as a core subject; prior to this the content of the science taught was at the discretion of the school. Within the new science course, breadth and balance were fundamental. Breadth required that attention was given not only to pupils gaining science knowledge, but also an understanding of the ways that scientists worked, and the skills needed by scientists. Balance designated that content was taken from across Biology, Chemistry and Physics. No longer was there to be the stereotyping of 'Physics/Chemistry' for the boys and 'Biology' for the girls.

Prior to the curriculum changes in 1991, there had been a growing recognition that school science was narrow and over-academic; in most post-

primary schools Biology, Chemistry and Physics were timetabled separately from age 11 - the start of post-primary education. The emphasis was firmly on knowledge and understanding. For the lower ability pupils there was less structure with the focus often on application. For example, some pupils in post primary schools could be timetabled for 'Gardening'. Practical activities were encouraged and, in the main, were used to support the attainment of knowledge and understanding. This was often at the expense of young people gaining an insight into the methodology of science exploration and investigation.

The introduction of a statutory curriculum made a profound difference to science teaching in primary schools. Science was being taught in primary schools (for 4 to 11-year olds) before 1990 but the content mainly reflected the knowledge and/or interests of particular class teachers - examples would be a study of birds or plants. A change in teacher/class would result in the study of new topic(s), with little opportunity for progression in science knowledge and understanding.

Statutory Science

The original curriculum

The statutory curriculum, introduced in 1991, was subject based. Working groups, made up of teachers, and other professionals with subject-specific expertise, were mandated to set out subject content appropriate for learners aged 4-16. The first subjects introduced were English, Mathematics and Science, with other subjects subsequently phased in; for example, Geography and History followed a year behind E/M/Sc. For each subject, content was set out within age-related Key Stages (KSs). The primary school KSs were:

- Key Stage 1 covering 4 to 8-year olds;
- Key Stage 2 covering 8 to 11-year olds.

Post-primary schools also had two Key Stages:

- Key Stage 3 covering 11 to 14-year olds;

- Key Stage 4 covering 14 to 16-year olds.

In order to provide for differentiation, ‘Statements of Attainment’ across 10 levels were drawn up to indicate progression. For example, ‘Force’ was introduced as simple ‘push and pull’ at Level 1 and then developed to introduce the complexities, i.e. gravitational force, at higher levels. In Chemistry, in Level 1 the concept of chemical change as opposed to physical change was introduced, with chemical reactions and equations being developed at higher levels.

New areas were introduced:

- How Science works;
- What scientists do.

Knowing the science is important but being able ‘to do science’ by acting scientifically, and applying scientific knowledge, understanding and skills is of equal importance. These new areas were introduced in order that young people should acquire scientific skills and competencies and know how and when to use their science in positive ways. Communication of scientific knowledge was emphasised in order that young people experienced science in action. While these requirements met with initial concerns for teachers, they led to significant developments in practical work and cross-curricular projects in primary schools. Inspection reports on the new curriculum praised the exciting investigative work being undertaken by children as young of 5/6, particularly with activities relating to ‘fair’ testing.

The subject-based statutory curriculum in primary schools did succeed in establishing an entitlement and an indication about how content could be linked to age and ability. However, fundamental problems and concerns emerged.

- Primary teachers were not used to, nor did they want, a subject-based curriculum. A primary school principal said at a major conference in 2002, ‘*we work on cross-curricular topics and to enable us to continue to do this, we ‘chop up’ the subject requirements and re-align them in ways that work for our teachers*’;
- Primary teachers were science ‘experts’ but described themselves as generalists in terms of subject knowledge. Moreover, The Royal Society ‘State of the Nation’

report (2010) suggested that, ‘*many primary teachers have a significant deficit in their science background*’.

With post-primary schools the main issue was the volume of the overall content. When all the subjects were brought together, the content was ‘overwhelming’. This was particularly the case at Key Stage 4 -for 14 to 16 -year olds. One post-primary principal described the curriculum planning as attempting to put a quart of curriculum into a pint pot of timetable time. Quote: ‘*120 per cent of statutory curriculum can’t fit into the 100 per cent of a 40 period weekly timetable*’.

A general concern for schools was that important cross-curricular skills were being ignored in order that the statutory content was covered. In science, this had implications for the nature and scope of practical work. After a few years of implementation of the new curriculum, there was a growing demand for change, and this led to a fundamental curriculum review.

The revised Curriculum

The Northern Ireland Council for the Curriculum, Examinations and Assessment (CCEA) was charged with undertaking the review of the requirements of the statutory curriculum. The revised curriculum, approved in 2004, was informed by a considerable body of research and consultation. Implementation began in 2007. A significant change was the removal of some of the content, particularly at Key Stages 1 and 2. This was done to enable teachers to choose the content appropriate for their pupils. The focus was now much more on the skills and competences required for life and work.

The changes meant:

- greater flexible for teachers in their curriculum planning;
- more opportunities to develop a cross-curricular approach; and
- increased relevance of what is taught and learned to the world outside the classroom.

Primary

The structure of the curriculum was changed with the statutory requirements no longer defined by subject but organised into ‘Areas of Learning’. For example, at Key Stage 2, there are seven

‘Areas of Learning’: The Arts; Language and Literacy; Mathematics and Numeracy; The World Around Us; Personal Development and Mutual Understanding; Physical Education; and Religious Education. The revision saw the amalgamation of Science, Technology, Geography and History into a single Area of Learning - entitled ‘The World Around Us (WAU)’.

A new Foundation Stage, comprising the first two years of schooling, was introduced. This was designed to promote open-ended, interactive and practical learning experiences for children in the early years of their education. There was a new structure:

- Foundation Stage covering 4 to 6-year olds;
 - KS 1 covering 6 to 8-year olds
 - KS 2 covering 8 to 11-year olds
- (KS 3 and KS 4 remained as before).

Science in primary schools was no longer a discrete subject with a defined content. Furthermore, there was no stipulation for teachers to spend specified time on the component parts of WAU, namely Science, Technology, Geography and History. The WAU requirements were divided into four strands: Interdependence; Place; Movement; and Energy. Learning intentions for each of these strands were provided as guidance for teachers on how content across the four strands could be brought together to cover the constituent elements of WAU.

The revised curriculum took account of the need, particularly in primary schools, for a cross-curricular approach and the importance of enabling cross-curricular skills to be developed. Teachers gave a strong welcome to the changes as content had been reduced and they felt they had more control over what they taught. Some members of the science community, however, had concerns about the less stringent content requirements. There is some evidence to suggest that the time allocated to primary science has decreased since the introduction of the revised curriculum. The teaching of the physical sciences has been seen to suffer the greatest decline. This may reflect a collective lack of science subject knowledge across the primary teacher workforce.

The General Teaching Council NI (GTCNI) – the body responsible for maintaining records of the teaching workforce - does not register teachers according to subject specialism. However, in 2008

they did investigate the numbers of teachers on their register that held one or more Science, Technology, Engineering and/or Mathematics (STEM) teaching qualifications, or other academic STEM qualifications. This showed that only around 20% of all primary teachers registered in Northern Ireland had a science background, and the number of physics specialists working in primary schools was negligible. It is worth noting that a study carried out by W5 (the Interactive Science Centre in Belfast) has indicated that many primary teachers said they enjoyed teaching science.

Post-primary

Key Stage 3

This KS covers the first three years (11 to 14-year olds) of post-primary education. As was the case for the primary sector, the curriculum review at KS 3 resulted in a reduction in content, with detailed programmes of study replaced with minimum requirements set within a skills framework. This was to allow greater freedom for teachers to tailor learning to meet the needs/abilities of their pupils.

KS 3 Science, unlike KSs 1 and 2, is a designated discrete subject within the Science and Technology Area of Learning. The statutory science at KS 3 requires that pupils should have opportunities to:

- develop skills in the scientific method of enquiry in order to further their scientific knowledge and understanding;
- develop creative and critical thinking in the approach to solving scientific problem, including researching scientific information from a range of sources, developing practical skills -including the safe use of science equipment; and
- learn about - Organisms and Health, Chemical and Material Behaviour, Forces and Energy, and the Earth and the Universe.

KS 3 Guidance for science teachers cites flexibility as one of the ‘key messages’. Teachers were required to devise schemes of work tailored to meet the needs and aspirations of their pupils. While the statutory requirements were to be covered, teachers had a degree of freedom to build on the specified content. Guidance also covered lesson planning and interpreting content requirements. While there is continuity in content

across KS's 1 and 2 and KS 3, Inspectorate reports argued the need for joint planning between primary and post-primary schools in order to avoid repetition of learning across the KS 2 (primary) and KS 3 (post-primary) boundary.

Key Stage 4

KS 4 covers 14 to 16 year-olds - the last 2 years of compulsory education in Northern Ireland. This proved to be the most difficult area to address in the revision of the statutory curriculum, mainly because the state examinations, particularly the General Certificate of Secondary Education (GCSE), kick in. Schools saw a conflict in ensuring that a statutory curriculum content was to be covered while, at the same time, the GCSE specification requirements were to be fulfilled.

In science, there were particular issues. The original statutory curriculum at KS 4 had specified a 'balanced' content made across Biology/Chemistry/Physics. However, schools wanted flexibility to enable a range of GCSE science options to be available. This was a particular request from the grammar (selective) schools, who had always allowed their students to have the option to take 1, 2 or 3 separate (B/C/P) GCSEs.

The solution within the curriculum review was radical, with the introduction of much greater flexibility for schools. The statutory subject requirements were removed to be replaced by a curriculum framework made up of nine Areas of Learning (AoL).

- Language and Literacy
- Mathematics and Numeracy
- Modern Languages
- The Arts
- Environment and Society
- Science and Technology
- Learning for Life and Work (introducing new elements: Employability, Local and Global Citizenship and Personal Development) - *statutory*
- Physical Education - *statutory*
- Religious Education – *statutory*

The significance of the 'statutory' tag beside the last three AoLs, was that schools were required to ensure they were covered, though not necessarily through taking associated qualifications. DE placed great emphasis the new AoL 'Learning for

Life and Work (LLW)' - more about LLW follows. In addition, the four main churches were requested to develop a core curriculum for Religious Education.

Since GCSEs, and other applied qualifications, assume such significance for 14 to 16-year olds', a new statutory requirement was introduced - qualifications offered to students at KS 4 had to be monitored by the Department of Education (DE) through an approval (termed accreditation) process, operated by CCEA in its role as the regulator of qualifications.

The outcome of the KS 4 review for science meant much greater flexibility. A balanced content, including elements of B/C/P could be offered or, alternatively, 1, 2 or 3 of the separate sciences was available in schools. GCSE developments facilitated this flexibility, with the following science specifications available:

- Single Award (SA) and Double award (DA) - each of these GCSEs covered appropriate elements of B/C/P. DA, as the title indicates, has twice the content of SA and is awarded double grades i.e. AA, BB etc.
- Separate science GCSEs in Biology, Chemistry and Physics allowed for 1, 2 or 3 sciences to be studied.

As was the case in the primary sector, there was a welcome in post-primary schools for the greater flexibility introduced at KS 4, in particular within Science Departments. However, as was the case with KS's 1, 2 and 3, there was criticism of the relaxation in the subject content requirements - particularly within the wider science community. There is a body of opinion that saw the changes as removing broad and balanced science, and as allowing a reduced science content to be available to 14 to 16 year-olds - the debate continues.

However, there is still an overall curriculum requirement for breadth and balance at KS 4. This is interrupted as schools meeting the requirements of the Key Stage 4 curriculum Framework as well as the needs of all their young people. Guidance requires schools to consider to what extent their curriculum is broad and balanced as defined by the following characteristics:

- meeting the aims of Northern Ireland Curriculum;
- empowering young people to achieve their potential and to make informed and responsible decisions throughout their lives; and
- developing young people as individuals, as contributors to society and to the economy and environment.

The curriculum for 14 to 16-year olds needed to be pupil-centred and reflect the diversity of needs, abilities and aspirations of all learners. Pupils should have opportunities to select from a range of subject options and accredited general (and applied) qualifications that have currency with employers, colleges of Further Education and Universities. Furthermore, there continues to be a focus on improving standards in literacy and numeracy across all subjects.

LLW was identified as contributing to learning at KS 4 by providing: careers education and planning; opportunities to develop employability skills and experiential learning in the workplace and the community. There was also the requirement to introduce opportunities to develop 'cross-curricular' skills and thinking skills and personal capabilities, building on what had been acquired at Key Stage 3. A modular LLW GCSE is offered in Northern Ireland

Curriculum progression

A major requirement of curriculum development has been a focus on progression. With the Key Stage framework there was a recognition that learning occurs at different rates depending on the ability of learners. Continuity across the key stages is important and is facilitated through the progression statements that enable progress to be reported by levels. This system works best across KS 1 and 2 - in primary schools. However, the move to the post-primary schools (at 11 years of age) means greater thought needs to be given to reporting progress across KS 2 and 3. This is an area that has caused much discussion.

The differences in curriculum and assessment across KS 3 and KS 4 mean that 14 to 16-year olds curricular experiences are tied in the courses and qualifications (specifications) taken. However, the curriculum at Key Stage 4 should still enable pupils to build on their prior learning and achievements from KS 3. Guidance emphasises that at KS 4 teachers need to move beyond a narrow focus on content to introduce a

broader focus that includes skills. This is important as progression in learning is not just about the subject content attained but also ensuring learners move from dependence on teacher input to independent learning and from shallow, surface understanding to deep learning.

The Qualifications Landscape

The impact of externally accredited qualifications, particularly GCSE and A Level, in driving curriculum change for 14 to 19-year olds required further thought as to how curriculum controls could be put in place. A further statutory requirement was introduced - the Entitlement Framework (EF). The EF sets out the minimum number and range of courses, including both academic and vocational, that a school should offer at KS 4 and Post-16. The courses offered need to be economically relevant with clear progression pathways to higher/further education and/or employment. This was to guarantee that all 14 to 19-year olds would have access to a minimum number of courses at Key Stage 4 and Post-16, of which at least one-third were to be general (academic) and one third applied (vocational).

Schools are encouraged to make use of up-to-date labour market information and to take note of priority skills areas in offering access to a coherent and economically relevant courses for their learners. With the new focus on applied/vocational courses, schools are encouraged to work in collaboration with neighbouring schools and with colleges of further education. To facilitate collaboration between schools and colleges, a network of Area Learning Communities (ALCs) was set up. There are currently 27 ALCs, which are commonly made up of between six and ten schools, and local college(s). Every post-primary school in Northern Ireland has membership of an Area Learning Community (ALC). This provides a mechanism within which schools can come together, with colleges, to plan the curriculum they offer. The EF enables schools to offer both a broad and balanced, and economically-relevant curriculum that meets the needs, abilities and aspirations of all their students.

Government was keen that all 14 to 19-year olds in schools were offered a broad relevant curriculum. To this end, CCEA, as the qualifications' regulator, was commissioned to undertake a development project with schools and Learning Support Centres (LSCs) within the

special educational needs sector. The purpose of this work was to inform how the Entitlement Framework could apply to this sector. The outcome is that special schools and LSCs should provide relevant and achievable courses (or units of courses) that offer recognisable and transferable progression for individual learner. The project concluded that all special schools and LSCs should aim to identify learning programmes covering three curriculum areas: literacy/numeracy; Learning for Life and Work; and a vocationally-related element.

The Qualifications Landscape

A review of curriculum development covering up to Post-16 would not be complete without reference to qualification reforms, in particular to GCSE and A-Levels. In Northern Ireland, qualification specifications define the curriculum for 14 to 19 year-olds. At KS 4 (14 to 16 year-olds) the main qualification is the General Certificate in Secondary Education (GCSE) and for Post-16 students the General Certificate in Education (GCE)-more commonly referred to as A-Levels. While GCSE and A-Level currently have substantial market share in schools here, there is increasing interest in and use of vocational/applied qualifications, as they provide greater breadth of study and make the qualifications on offer more inclusive.

GCSE

The GCSE brand was introduced in 1988 as a qualification that aligned with the end of the statutory period of education. It replaced the Certificate in Secondary education (CSE) and the more academic O-Level qualifications. GCSEs were initially graded by a letter scale-from A to G, with the Grade C being seen as roughly equivalent to the old O-Level Grade C and CSE Grade 1. In 1994 an A* Grade was added above the Grade A to further differentiate at the higher end of achievement. Initially, GCSEs were available in a narrow, mainly academic, range of subjects. Over time, the range of subjects offered was expanded with various new titles being added, including: modern and ancient languages; in vocational areas, such as Electronics; and expressive arts, such as Dance, as well as specifications covering citizenship courses. Within the sciences there was considerable curriculum development in England during the 1970/80s and this led to the introduction of a range of new and innovative GCSE specifications.

One example was 'Salters' Science'. This was a complete teaching programme with an applications-led approach. The course was topic based with each topic having its origin in materials, phenomena or ideas which would be familiar to students or of value to them in their everyday lives. These provided starting points to illustrate scientific principles/laws. The Salters' Science materials were developed by teams of science teachers working with the University of York Science Education Group. The Salters' curriculum led to the development of a Double Award GCSE Science, supported by 'Science Focus' which was a KS 3 (11 to 14) programme with a similar approach to teaching and learning. In the early 90s, additional modules were developed to provide the extension materials needed to complete separate GCSE Salters' specifications in Biology, Chemistry and Physics.

Between 2005 and 2010 a variety of reforms was made to GCSE qualifications, including increasing modularity and with changes to non-examination assessment, including how practical skills in science were assessed. From 2010 controlled assessment replaced coursework, requiring more rigorous examination-like conditions for much of the non-examination assessed work. Some science teachers saw this as reducing the value of 'practicals', while the broader view taken was that greater rigour had been introduced.

The aim of increasing rigour and maintaining standards has dominated GCSE development over the last 10 years. GCSEs are now required to meet strict qualification and subject-specific criteria that cover content and assessment requirements. There is, therefore, less opportunity for creative specification development with the result that both the range and number of GCSE titles has been reduced over the past decade.

There continues to be GCSE specifications offered by:

- AQA, OCR and Pearson -Exam Boards based in England;
- WJEC in Wales; and
- CCEA in Northern Ireland.

However, the specifications offered are very similar in content and assessment arrangements.

From 2015 a large-scale programme of GCSE reform began in England, in particular with changes to the structure and grading system. The new GCSEs are designed such that all assessment is taken at the end of a full 2-year course - linear assessment, with no interim modular assessments, coursework, or controlled assessment, except where necessary, such as in Art and Design. Subject teaching can retain coursework on a non-assessed basis, with the completion of certain experiments in science subjects being assumed in the theory examinations.

The other main change is the move to a numerical grading system, with Grades 1 to 9 (highest) introduced. However, the grading changes are not universal and are limited to the English-based GCSE Exam Boards. WJEC has not changed its A* to G grades. In Northern Ireland, the A* to G grade scale is maintained, with the A* Grade aligned to the Grade 9 on the English reformed qualifications. A new C* grade was also introduced in Northern Ireland to align to the numerical Grade 5. GCSEs offered by CCEA in Northern Ireland remain modular and science practical assessment continues to count towards the overall grade achieved.

A Level/GCE

GCE (better known as A-Levels) qualifications are college or school based leaving qualifications offered across England, Wales and Northern Ireland. Their main function is to support entry to Higher Education. The five Exam Boards listed under the GCSE section also administer A-Levels. The most significant A Level developments resulted from a '*Review of Qualifications for 16-19 year-olds*' undertaken, at the behest of Government in England, Wales and Northern Ireland, by Sir Ron (later Lord) Dearing). As with GCSEs there has been a range of measures over the past decade to rationalise GCE provision and to ensure common standards.

The Dearing changes resulted in A-level specifications made up of six content units - three of the units being defined as 'Advanced Supplementary (AS)'. The AS units were designed to be intermediate in demand between GCSE and A-Level, and were taken in the first of the two year A-Level study programme. The overall A-Level grade received by a student was made up of equally weighted contributions from AS Level and A2 Level achievement. It was intended that most post-16 students would take 4/5 AS-Levels and then reduce their study in the

second year to 3 or 4 A-Levels. Dearing saw his recommendations as a way of increasing breadth within sixth study, while maintaining the A-Level brand. After a number of years of implementation changes were made to Dearing's plans, with a reduction in AS Levels taken and the number of units - in the main from 3 to 2 for each of the AS and A2 units.

Between 2015 and 2018 A-Levels in England were reformed. A major element of the reform was transitioning from modular to linear assessment. This means all A-Level exams are taken in one sitting as a set of terminal exams - three exams for the majority of subjects, at the end of one year's study. In addition, there is no mark for coursework included in the assessments for most subjects. The move to linear assessment means that AS and A-Levels are de-coupled, with AS Levels being separate qualifications.

Opposition to these reforms in Wales and Northern Ireland has resulted in WJEC and CCEA maintaining the modular structure of their qualifications and for the AS/A2 link continuing. There was a further reform to the GCE Sciences in England; the grade awarded is now based solely on the written (theory) papers with the assessment of practical skills simply listed as a 'Pass' on the certificate - if a candidate has completed the practical assessments stipulated. It was decided by government here (and in Wales) that practical assessment (contributing 15% of the marks) would continue to contribute to the overall grade. The overall result of the most recent changes is that the uptake of reformed 'English' specifications in Northern Ireland is low; with CCEA specifications now taking over 90% market share here. There are subject micro-sites on the CCEA web-site that will allow all CCEA GCSE and GCE specifications to be viewed.

The Post-16 Curriculum

The impact of externally accredited qualifications, particularly GCSEs and A-Levels, in driving curriculum change for 14 to 19 year-olds required further thought by government here as to how controls could be put in place. A further statutory requirement was introduced - the Entitlement Framework (EF). The EF sets out a minimum number and range of courses, including both academic and vocational, that schools should offer at KS 4 and Post-16. At least one third of the courses (qualifications) need to be general (academic) and one third applied (vocational). This is to guarantee that all 14 to 19 year-olds

have access to an enriched and relevant curriculum.

Schools are encouraged to make use of up-to-date labour market information and to take note of priority skills areas in offering access to coherent and economically relevant courses. With the new focus on applied/vocational courses, schools have been enabled to work in collaboration with neighbouring schools and with colleges of further education. To facilitate collaboration a network of Area Learning Communities (ALCs) has been set up. There are currently 27 ALCs, which are commonly made up of between six and ten schools, and local college(s). Every Post-primary school in Northern Ireland has membership of an Area Learning Community (ALC). This provides a mechanism whereby schools can come together, with colleges, to plan the curriculum they offer. The EF enables schools to offer both a broad and balanced, and economically-relevant curriculum that meets the needs, abilities and aspirations of all their students.

Government was keen that all 14 to 19 year olds in schools were offered such a broad relevant curriculum. To this end, CCEA, as the qualifications' regulator, was commissioned to undertake a development project with schools and Learning Support Centres (LSCs) within the special educational needs sector. The purpose was to inform how the Entitlement Framework could apply to this sector. The outcome is that special schools and LSCs should provide relevant and achievable courses (or units of courses) that offer recognisable and transferable progression for individual learner. The project concluded that all special schools and LSCs should aim to identify learning programmes covering three curriculum areas: literacy/numeracy; Learning for Life and Work; and a vocationally-related element.

Conclusions

The difficult balance of ensuring entitlement while, at the same time, enabling differentiation has been achieved. This did require a review of the initial statutory curriculum and the introduction of greater flexibility. In the main, schools believe that they have a curriculum model that works, although teachers and school leaders that 'lived' through the changes will say, quote: 'It was an exhausting experience but we got there in the end!' Qualifications reform has meant greater robustness in standards. Some would say

this is a good thing, others that creativity and choice have been reduced. The introduction of the statutory curriculum requirements and qualification reforms have impacted significantly on schools. It has meant that a robust programme of learning is offered to all.

Biography

Roger McCune read Chemistry at Queens University Belfast and began his teaching career in the Boys' Model School, Belfast, before moving to Ballyclare High School (BHS). He completed a Master's degree in Chemical Education at the University of East Anglia in 1976 and was made Head of Chemistry in BHS in 1977. He moved to the Ulster Polytechnic (now Ulster University) in 1984 to head up the Northern Ireland Science and Technology Regional Organisation (NISTRO). Roger joined the newly established Northern Ireland Curriculum Council (NICC) in 1990 and was Head of Regulation at the Council for the Curriculum, Examinations and Assessment (CCEA) from 1976 until he retired in 2019. In 2012, he was awarded an MBE for services to education in Northern Ireland. Roger is a former national Chair of the Association for Science Education (ASE) and is a Fellow of the Royal Society of Chemistry (RSC).

Editor: I asked Roger a question about exam boards in N. Ireland and A-level Chemistry (equivalent to but higher than LC Chemistry), and the choice of exam boards and different syllabi by schools in N. Ireland. This was his reply.

In the main the answer is that there is choice of A-Level specifications here so in most subjects, e.g. Geography students can do CCEA or WJEC (Welsh board) or any of the 3 English Boards - AQA, Pearson or OCR.

In practice, the uptake of the English specifications is low because in England all A-level specifications are Linear and not linked to the AS levels. With CCEA (as in Wales) the specifications continue to be modular, with the 3 AS modules contributing 40 per cent of the marks to the overall A-level grade.

Now to the three sciences (P/C/B) - in England it was decided that the A-level grade awarded would be based solely on the written (theory) papers with the assessment of practical skills simply listed as pass (if candidate has completed the practical assessments stipulated) on the

certificate. Our minister (John O'Dowd) decided that he wanted the practical assessment (15 per cent) to contribute to the overall grade - this is also the case in Wales so students in N. Ireland could do WJEC specifications in science but in the main it is a closed market with CCEA science specifications having a monopoly.

At A-Level could theoretically have a choice of up to 6 different Chemistry syllabi, including Salters' A-Level Chemistry. By accessing the

websites of the different exam boards you can see the detail and resources provided to teachers for each syllabus. At GCSE schools can choose to enter students for single award, or double award science or in individual science subjects (B, C, P), offered by the different exam boards. This gives schools and teachers in N. Ireland a choice unheard of in the Republic.

□

Quotes on education

“Education is the ability to listen to almost anything without losing your temper or your self-confidence.”

Robert Frost

“To live for a time close to great minds is the best kind of education.”

John Buchan (1940)

“Schools waste two-thirds of the talent in society and universities sterilise the other one-third.”

Edward de Bono

“Liebig was not a teacher in the ordinary sense of the word. Scientifically productive himself in an unusual degree, and rich in chemical ideas, he imparted the latter to his advanced pupils, to be put by them to experimental proof; he thus brought his pupils gradually to think for themselves, besides showing and explaining to them the methods by which chemical problems might be solved experimentally.”

Hermann Kolbe

“Most teachers waste their time by asking question which are intended to discover what a pupil does not know whereas the true art of questioning has for its purpose to discover what pupils knows or is capable of knowing.”

Albert Einstein

Chemistry in the Institutes of Technology Ireland – forty years of change

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When the first *Chemistry in Action!* came off the press in 1980, the first set of Institutes of Technology (IoT) were just ten years old. The 1960s had seen a change in the industrial manufacturing landscape in Ireland and *The Training of Technicians in Ireland* (1964) report identified significant skills gaps, including technician level, and advocated the development of a high-quality technician diploma that would be attractive to students, parents and employers. [1]

The *Mulcahy Report* (1967), more formally *The Steering Committee on Technical Education*, framed the structures of these new institutions, that would educate for trade and industry over a broad spectrum of occupations ranging from craft to professional, notably in engineering and science but also in other specialities. Their immediate remit was to provide courses aimed at filling gaps in the industrial manpower structure, particularly in the technician area. Long term they were to evolve and adapt to meet social, economic and technological changes, responding to local initiatives, and develop their educational provision as required.

The building programme for the new colleges commenced in 1968, and five colleges opened in 1970, with other colleges established during the following decade. Some colleges (Dublin Institute of Technology and Limerick College of Art Commerce and Technology (CoACT)) developed from earlier institutions and colleges, involving amalgamation, but most were completely new

institutions. The institutions were run under Section 21 (2) of the Vocational Education Acts from 1970 until 1992, as special subcommittees of the Vocational Education Committees and placed on an independent basis thereafter by the Regional Technical Colleges Acts in 1993.

In 1980-81, some 10,910 students were attending either Vocational Technical Colleges or the nine Regional Technical Colleges (RTC), which was 26.0% of the total enrolment at third level. [3] The latest statistics from the Higher Education Authority (HEA) are dated to March 2018. At that date the total enrolment at third level full-time undergraduate was 159,823 students. Of that number 64,784 students were enrolled in Institutes of Technology.[4]

One of the first tasks we completed at the Schools Information Centre on the Irish Chemical Industry (SICICI)* was a survey of all the chemistry and allied courses at third level in Ireland in 1990. At that time most of the Technical Colleges were offering Certificates (level 6) and Diplomas (level 7), while some still offered the City & Guilds technician courses. [5]

The response to industrial needs for graduates at these levels was mirrored in the course names, many of which included terms like 'Applied Chemistry' or 'Chemical Analysis'. The development of the chemical and allied industries (including pharmaceuticals) was a driver at a regional level for course development in the Regional Technical Colleges. Some of the

significant industrial developments around the country included:

1959: Leo Laboratories set up Ireland's first manufacturing operation

1960's: Manufacturing begins to grow in Ireland, with a focus on Active Pharmaceutical Ingredients (API)

1969: Pfizer Chemical Corporation opens first large-scale fine chemical plant in Ireland at Ringaskiddy, Co. Cork.

1973: Marathon discovers natural gas off Kinsale, brought ashore in 1978.

1974: Merck, Sharp and Dohme locates at Ballydine, near Clonmel, Co. Tipperary.

1974: Wyeth opens first Irish operation in Askeaton in Limerick. The nutritional plant becomes one of the leading producers in Europe of infant and child nutritional products, including powdered milk.

1977: Syntex (Roche) locates at Clarecastle, Co. Clare.

1979: Premier Periclase starts producing magnesia from seawater at Drogheda.

1983: Auhinish Alumina (Rusal) starts production at Auhinish Island, Co. Limerick.

1989: Sandoz (Novartis) lodges planning application for a £250 million plant at Ringaskiddy. Planning permission was granted by Cork County Council in 1990, subject to 77 stringent conditions, and full production started in 1995.

1990's: Shift towards high value secondary manufacturing Oral Solid Dose and Vaccines among others

2000's: Ireland established as location of choice for biopharmaceutical operations with set up of the world's largest bioprocessing facility by Wyeth in Grange Castle

Today: Ireland is the world's largest net exporter of pharmaceutical products. 50% of all of Ireland's manufactured exports are pharmaceutical products.

Over time the course offerings at the Technical Colleges expanded to include level 8 (Honours degrees) and qualifications at postgraduate level – both taught and by research. What distinguishes the suite of programmes in IoTs is that most colleges still maintain the 'ladder system', whereby students entering on a level 6 programme

can progress to level 7 and level 8 and beyond. Market demand and competition has seen many colleges introduce *ab initio* level 8 degrees as well as the 'ladder' offering.

In the late 1990s, all the institutions were upgraded to Institute of Technology (IoT) status. This was in recognition of the high standards, including university level research, which takes place at them. They now offer qualifications from Level 6 (Higher Certificate) to Level 10 (Ph.D.). Institutions have been given delegated authority to confer their own awards in some cases up to Doctoral level.



Locations of Institutes of Technology in Ireland
(<https://www.educationinireland.com/en/Where-can-I-study-/View-all-Institutes-of-Technology/>)

Currently there are eleven Institutes of Technology (see map above), since three of the original fourteen amalgamated in 2019 to form Technological University Dublin. Just as many of the company names listed above have changed over the years, so have the offerings in chemistry and chemistry related courses in the Institutes. The current chemistry related courses are shown in Table 1. All courses listed have chemistry-themed modules as a significant component. The importance of the pharmaceutical and biopharmaceutical industries to the local and national economy is reflected in many of the course titles.

Table 1: Sample Chemistry-related Courses in Institutes of Technology 2020
(for clarity alternate courses are in bold)

Institute of Technology (IoT)	Level 6	Level 7	Level 8 (<i>add-on</i>)	Level 8 (<i>ab initio</i>)
Athlone IT	Science – Applied Science	Biotechnology Pharmaceutical Sciences – Drug Development & Analysis	Toxicology	Biotechnology Pharmaceutical Sciences
IT Carlow	Science – Applied Chemistry Pharmacy Technician	Biosciences Analytical Science		Pharmaceutics & Drug Formulation Brewing & Distilling
Cork IT		Analytical & Pharmaceutical Chemistry Physical Sciences – common entry	Analytical Chemistry with Quality Assurance	Pharmaceutical Biotechnology
Dundalk IT		Pharmaceutical Science Bioscience	BioPharmaceutical Science	Biopharmaceutical Science Environmental Bioscience
Galway Mayo IT		Common Science – undenominated Applied Biology & Biopharmaceutical Science Chemical & Pharmaceutical Science	Chemical & Pharmaceutical Science Forensic Science & Analysis	Science – undenominated
Letterkenny IT	Pharmacy Technician	Bioscience Pharmaceutical & Medicinal Science	Bioanalytical Science	Science Common entry Bioanalytical Science Pharmaceutical & Medicinal Science
Limerick IT	Applied Chemistry	Forensic & Pharmaceutical Sciences	Chemical Instrumentation and Analysis	Drug & Medicinal Product Analysis Forensic & Pharmaceutical Sciences Biotechnology & Biopharmaceutical Sciences
IT Sligo	Science	Environmental Science with Ecology Forensic Science & Investigation Pharmaceutical Science with Drug Development		Environmental Science (with Ecology) Forensic Science & Investigation Pharmaceutical Science with Drug Development Science
IT Tralee	Pharmacy Technician	Pharmaceutical Science		Pharmaceutical Science
Waterford IT		Science Pharmaceutical Science		Science Pharmaceutical Science Molecular Biology with Biopharmaceutical Science

Information sourced on Institute websites

Many of the institutes currently offer upskilling and reskilling programmes, usually on a part-time basis to enable participation by employees who wish to upskill or reskill. These courses may be under the auspices of Springboard. The Springboard+ upskilling initiative in higher education offers free courses at certificate, degree and master's level, leading to qualifications in areas where there are employment opportunities in the economy. The current range of courses in Springboard+ includes chemistry-related areas like (bio)pharmaceuticals, pharmaceutical technology, medical devices. Springboard+ is co-funded by the Government of Ireland and the European Social Fund as part of the ESF programme for employability, inclusion and learning 2014-2020. [6]

There is a political will to form mergers between Institutes of Technology on a strategic basis to develop Technological Universities. This is an ongoing situation and the enactment of the Technological University (TU) legislation in March 2018, (Technological Universities Act, 2018) set out a process whereby consortia might submit an application for TU designation. It is envisaged that these new TUs will maintain the options to study at levels 6 through 8 but expand offerings at postgraduate level.

As of 2019, there is currently one designated technological university and four consortia engaged with the process to become designated as technological universities:

- Technological University Dublin, designated January 2019 (amalgamation of DIT, IT Tallaght and IT Blanchardstown)
- Technological University for the South-East Ireland (TUSEI), consisting of Waterford Institute of Technology and Institute of Technology Carlow
- Munster Technological University (MTU), consisting of Cork Institute of Technology and Institute of Technology Tralee
- Connacht Ulster Alliance (CUA), consisting of Galway-Mayo Institute of Technology, Institute of Technology Sligo, and Letterkenny Institute of Technology.
- Athlone Limerick Technological University (ALTU), consisting of Athlone

Institute of Technology and Limerick
Institute of Technology.

The IoT sector is represented by the Technological Higher Education Association (THEA) and they summarise the sector as follows: *"The technological sector is recognised as a major success story in Irish education. Its members provide undergraduate and postgraduate programmes of study with a strong focus on the needs of the individual and the workplace, while promoting equality of access, and seamless transfer and progression, to and through programmes of study. They have been at the forefront in developing new programmes in the areas of greatest skill demand, often working in partnership with industry to provide new modes of delivery.... This has led to an enhanced level of participation by industry in the education process, in-career reorientation and continuing professional development of the workforce throughout the country. The sector also promotes a research ethos aligned with the development of a national innovation system and the promotion of entrepreneurship that meets the need of the individual, the economy, and society."*

References

- [1] Training of Technicians in Ireland (1964) OECD, Paris
<https://www.worldcat.org/title/training-of-technicians-in-ireland/oclc/551709199?referer=di&ht=edition>
- [2] The Steering Committee on Technical Education Report (1967) Irish Government Publications, Dublin
<https://www.education.ie/en/Publications/Policy-Reports/Steering-Committee-on-Technical-Education-Report-to-the-Minister-for-Education-on-Regional-Technical-Colleges.pdf>
- [3] <https://www.education.ie/en/Publications/Statistics/Statistical-Report-1980-1981.pdf>
- [4] <https://hea.ie/statistics-archive/>
- [4] <https://www.ipa.ie/education/no-artificial-limits-ireland%E2%80%99s-regional-technical-colleges.3889.html>
- [5] <https://springboardcourses.ie/>

All accessed January 2020

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Footnotes on Forty Years by Marie Walsh

*SICICI was a 'spin-off' from *Chemistry in Action!* that aimed to underpin the promotion of

teaching and learning in chemistry by collecting and collating information and gathering a resource collection that would be accessible to teachers. It contributed industry-related articles to *Chemistry in Action!* and developed a video library service as well as producing several publications and gathering a large collection of other resources. It administered a National Chemistry Week in a mammoth production that sent a package of chemistry promotion materials to every secondary school, library and college in the country. Another associated resource was the annual ChemEd-Ireland conference each October, the proceedings of which have in recent years been published in *Chemistry in Action!*

Over the years a series of postgraduate researchers in chemistry education became involved in what evolved into the Chemistry Education Research Group (CERG) – sharing the production space and forming associations that have lasted beyond the months or years of shared space. Some of them travelled the length and breadth of the country with science magic shows, others produced excellent teaching resources. Members of CERG have also been involved in several EU-funded science education projects and details of these and associated resources are available. Maria Sheehan has put together the *Chemistry in Action!* website and all back issues and other

resources like the Transition Year modules can be accessed there at <https://www.cheminaction.com>

Throughout our time with him Peter Childs has earned our respect for his energy and enthusiasm for chemistry and chemistry education. Thanks to sponsorship from different companies over the years many of his ideas became reality (even if we sometimes sighed at his entrances with the words “I was thinking we should...”) but most people wouldn’t realise just what a shoestring budget we worked with. Personally, I would like to thank Peter for allowing me to be part of the various initiatives – and to wish him continued energy and enthusiasm for chemistry, but first and foremost good health to share valuable time with his extended family.

Biography

Marie Walsh is a lecturer in the Department of Applied Science at Limerick Institute of Technology. She started working with Peter Childs on Chemistry in Action! and related activities in 1988. They jointly organised the ChemEd-Ireland conferences in Limerick until 2006.

□

ISTA Conference 2020 at the Explorium



What a good job the ISTA organised its annual conference before the shutdown – it ran from Feb. 7-8 in the Explorium, on the edge of Dublin. It was a great venue (see front cover) and there was

an interesting discussion of the transition from junior science to LC and Professor Áine Hyland gave a good talk. I was struck by the disquiet expressed by teachers on the new Junior Science course, and its examination, but also on the new Agricultural Science course and the new Computer Science course. They all seem to suffer from the same problem: an inadequate specification of the course, depending too much on learning outcomes at the expense of fleshing out the syllabus. This makes it difficult to teach and examine, and each teacher becomes an interpreter of the specification. **Is the NCCA listening to science teachers?** They weren’t in evidence at the conference and one doesn’t have great hopes that the LC subject development groups will take the message on board.

□

Chemlingo: softening up your lysis

Peter E. Childs

In the present Covid-19 crisis testing has been a crucial component of tracking and checking its spread. One limitation has been the shortage of reagents (chemicals by another name) used for lysis. Such chemicals disrupt the cell wall releasing its contents so that they can be multiplied and identified. Newspaper reports referred to ‘chemicals known as reagents’, which sounds strange to a chemist. A reagent (or reactant) is another name for a chemical that takes part in a reaction, not for some new sort of substance. A reactant is the starting material a chemical, while a product is the chemical produced in the reaction. They are all chemicals!

Lysis comes originally from the Greek word *luein* = to loosen, *lusis* means loosening, and they became in Latin *lysis*. The mention of lysis in the testing for the virus reminded me how common the suffix -lysis is in chemistry, but especially in biology and medicine. The suffix -lysis refers to decomposition, dissolution or breaking something down. Thus lysis breaks down the cell wall.

Think how common the word ending -lysis is in chemistry. Analysis is the breaking down of something in order to identify and measure its components. Electrolysis involves using electricity to break down a compound into its compounds e.g. the electrolysis of water to produce hydrogen and oxygen gases. The word electrolysis was introduced by Michael Faraday in 1834 on the advice of William Whewell, whom Faraday consulted when he wanted new names. Hydrolysis involves decomposing a compound in aqueous solution or using water, e.g. the hydrolysis of esters. Pyrolysis is decomposition brought about by heat and cryolysis by cold. In fact, there are dozens of words ending in -lysis, particularly in biology and medicine.

Spelling is always important in science. **Protolysis** is used of proton transfer between two species, which involves loss of proton by one reactant; autopyrolysis is internal proton transfer e.g. $2\text{H}_2\text{O} \leftrightarrow \text{H}_3\text{O}^+ + \text{OH}^-$. But **proteolysis** is the breakdown of proteins by an enzyme, as when fresh pineapple is used to tenderise meat. Autolysis is the self-destruction of cells; not needing any external reagent to do the job, the cell lyses itself.

□

*“God and the doctor we alike adore
But only when in danger, not before,
The danger o’er, both are alike requited,
God is forgotten and the doctor slighted.”*

John Owen (1771-1858) *Epigrams* (quoted in *The Times* 22/3/16)

CheMiscellany: Curieana

This selection of interesting items has turned into a celebration of Marie Curie (1867-1934). She is probably the best-known female scientist, a role model for women in both Physics and Chemistry, and the first person, and only woman, to win two Nobel Prizes. This focus was sparked by a new film *Radioactive*, based on Marie Curie's life, and due to be released in March 2020. Covid-19 has put paid to that but hopefully we will get to see it when cinemas reopen.



For the trailer see:

<https://www.youtube.com/watch?v=YT5g0U2WvQ0>

In 2011 Alan Alda (of MASH fame) wrote a play called *Radiance: the passion of Marie Curie* (highlights <https://www.youtube.com/watch?v=O-Y9bVkBQCQI>).

A German film titled *Marie Curie* (2016) is available on YouTube at <https://youtu.be/YwLsf6XREXk>.

To mark the IYPT in 2019 the RSC sponsored a lecture on *The Three Lives of Marie Curie*, available at https://youtu.be/B_XtCCZvk2U.



There was an earlier Polish/French film *Marie Curie: the courage of knowledge* (2016) and you can see the trailer at

<https://www.youtube.com/watch?v=7GJRElIo2K8&t=57s>

Marie Curie as probably the most famous female scientist is widely featured on postage stamps. The article, *An IYC Philatelic Tribute to Marie Curie* by Daniel Rabinovich, was published in *Science International* (33(6), 44-45, 2011) for the International Year of Chemistry in 2011 and the centenary of her Chemistry Nobel Prize.

http://publications.iupac.org/ci/2011/3306/curie_stamps.html

“There is nothing more wonderful than being a scientist, nowhere I would rather be than in my lab, staining up my clothes and getting paid to play.”

Marie Curie

Diary

2020

Many conferences in 2020 have been cancelled or postponed due to Covid-19.

8th NPSE 2020

19-20 March
Florence, Italy
<https://conference.pixel-online.net/NPSE/index.php>
CANCELLED

15th ECRICE

Weizmann Institute, Israel
ron.blonder@weizmann.ac.il
CANCELLED – postponed to 2022

26th IUPAC ICCE

Postponed to 26-30 January 2021
Lagoon Beach Hotel
1 Lagoon Gate Drive, Milnerton
Cape Town, South Africa
<https://www.icce2021.org.za/>

26th BCCE 2020

18-23 July
Oregon State University, Corvallis, Oregon,
USA
<https://bcce2020.org/>
CANCELLED

Symposium on Chemistry and Science Education

Science education, culture and sustainability in the digital age
23-25th September (postponed from May)
University of Ludwigsburg, Germany
<https://www.symposium-science-education.de/index.html>

ChemEd-Ireland 2020

17th October
UCC, Cork
d.kennedy@ucc.ie

Science Week 2020

26-30 November
<https://www.sfi.ie/engagement/science-week/>

BASF Summer School, UCC is cancelled for this year.

Chemistry Demonstration Workshop at UL is cancelled this year.

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

“Reading maketh a full man; conference a ready man; and writing an exact man. And, therefore, if a man writes little, he had needed have a great memory; if he confers little, he had need of a ready wit; and if he read little, he had need of much cunning to seem to know that he knoweth not”.

Francis Bacon *Essays "Of Studies"* (1625)

Information page

Sponsors

The sponsors whose logos are featured on the outer back cover mostly give donations of between €250 to €1,000 per year to enable the production and distribution of *Chemistry in Action!* free of charge to Irish Chemistry teachers. Some of these sponsors have been supporting the magazine since the first issue, and have helped to ensure its continuance over the last 40+ years. Their help is much appreciated.

Contributions wanted!

Contributions are always welcome to *Chemistry in Action!* providing the material is of interest to second-level chemistry teachers. Articles, experiments or demonstrations, teaching tips, book and AV reviews etc. are all welcome.

Send one hardcopy + diagrams and a copy on disc (or by email as a Word document) when submitting material.

You can contact the editor by email at: peter.childs@ul.ie or one of our assistant editors.

Internet version

The most recent back issues plus some TY Science modules and other resources are available at:

www.cheminaction.com

For information contact the web editor, Maria Sheehan at

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TY Science Modules

We have discontinued selling these modules as postage got too expensive.

Some of them are available online, free of charge, at our website:

www.cheminaction.com

In the next issue #116:

We will continue the 40th birthday theme with articles on:

- University Chemistry Education,
- Science outreach,
- the International Chemistry Olympiad

and hopefully, the development of the Irish biopharmaceutical industry.

In addition, there will be a historical article on Jacques-Alexandre-César Charles of Charles' Law and one on chemistry breakout rooms.

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National Centre for STEM Education

