



Current and Future Methodologies for Improving Teacher and Student Experiences of Chemistry in Schools: an Irish Perspective

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Abstract

In spite of the fact that Junior Cycle Science, which is approximately one-third Chemistry, has been made compulsory in up to 90% of schools in Ireland, after that level is reached participation in Chemistry decreases dramatically. The terminal examination at second level in Ireland, the Leaving Certificate, has less than fourteen per cent uptake by students for Chemistry. Factors that influence this include provision of the subject in schools, allocation of subjects to students within timetabling constraints and choice by students of the science and technology subjects. Choice of subjects is further influenced by attitudes to, experiences of and perceived usefulness of Chemistry, both by students and their guardians.

Several initiatives have been taken in recent years to address falling uptake of Leaving Certificate Chemistry but these appear to have made little impact on the numbers attracted to the subject. Industrial and governmental bodies have constantly reiterated the need for training in subjects that blend and enhance the Knowledge Economy. A number of research groups focussing on Chemical Education have been established at third level. A proposed new curriculum for Leaving Certificate Chemistry, with a more emphatic requirement for practical work, is currently in development.

This paper will present a review of the current situation and future prospects in Ireland for motivating more students to study Chemistry and more teachers to embrace the changes in Chemical Education which have become best practice in other countries.

1. Introduction

In spite of a number of initiatives over recent years, utilizing significant resources and funding, to promote Science, Technology, Engineering and Mathematics (STEM) subjects in Ireland, the numbers of students studying science and mathematics to higher levels has given cause for concern. The uptake of Chemistry as a Leaving Certificate subject has significantly declined since the 1980, dwindling to a current state where only 13.4% of the Leaving Certificate cohort opts to study the subject.

The poor uptake of science and mathematics at second level feeds on into third level. Students apply for third level places based on a points system and the points for science and mathematics courses have dropped considerably. Even more alarmingly, dropout rates of up to 39% have been reported recently for some university science courses.[1] Chemistry remains the central science supporting other Sciences but it now also underpins many new fields of scientific development such as Genomics, Biomedical Sciences and Materials Science. It is a worrying reality that many first year undergraduates require crash courses in what is seen as an essential subject for their degree studies. Overarching all of this is the fact that Chemistry is not being valued for Chemistry's sake.

This is disappointing on a number of levels: Ireland is in the midst of an economic recession and the science and technology -based industries which have kept the country afloat are constantly promoting the need for graduates to sustain the so-called 'Knowledge Economy' and to avoid a 'Skills Shortage'. However, there is still a strong public perception that jobs in science are neither plentiful nor prestigious, which contrasts sharply with the perception of highly paid prestigious careers in medicine, law and business areas. Unfortunately, Chemistry, like other sciences, will never attract its deserved quota of the brightest students until the public perception of science is radically changed. To this end the Chemical and Pharmaceutical industry





recommended adoption of *Hearts and Minds*, a strategy to ensure wide appreciation of the benefits the sector brings to Ireland.[2] They recommended that at first and second level, the education system should aim to do the following: Create teacher, student and parent awareness of the career opportunities afforded by taking mathematics, physics and chemistry at second level, and use secondary school scholarships and career opportunities as key incentives for students to study these and related technology subjects. Some of their suggestions have been implemented but what the strategy failed to address was the lifelong learning aspect of appreciating Chemistry as a worthwhile subject in its own right.

2 Chemistry in the Primary and Secondary Education System

2.1 Science in Primary and Secondary School

Chemistry is embedded in the Primary curriculum in a stream of Social Environmental and Scientific Education, which was formally introduced in 2003/4.

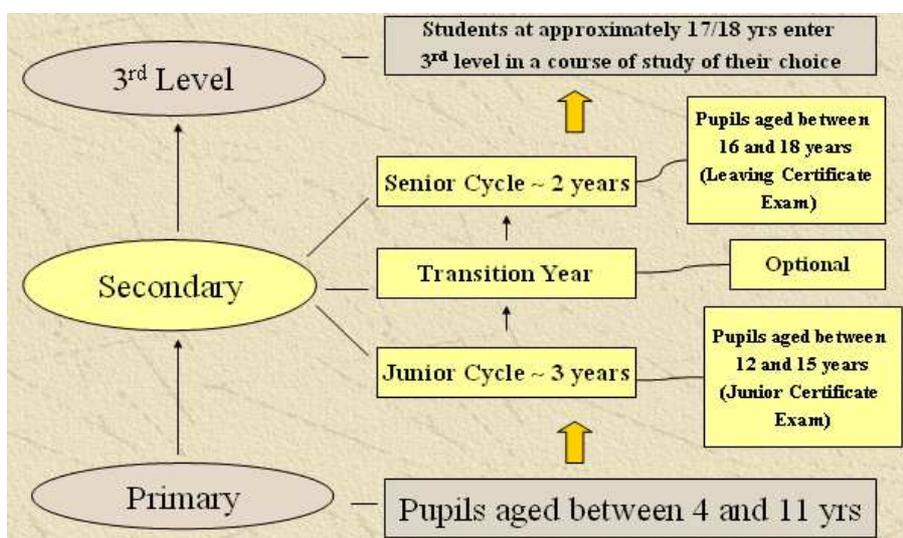


Figure 1: The Irish Education System

Science at lower secondary level is presented as a single subject with three distinct sections, one of which is Chemistry. Teachers have the option of teaching the sections separately or in a co-ordinated interdisciplinary manner. While Ireland is unique among 21 European nations in that Science is not compulsory at lower second level, up to ninety per cent of students study this subject. [3] Current discussion about curriculum reform is proposing that science will be made one of four compulsory core subjects for all at ISCED level 2.

Transition Year is an optional year between ISCED 2 and ISCED 3, which is generally taken by just under fifty per cent of all students, and where students get a 'taster' of various subjects. Science delivered in this year is usual in the form of short modules with attractive titles, e.g. Science and Sport, Environmental Science, Cosmetic Science, and the ubiquitous Forensic Science. The students may be learning about Chemistry without even realising it! However, one study has shown that the practice of science teaching in schools is promoting Chemistry: Few teachers have laboratory time for all of their science classes during Transition Year. Most teachers (62%) are teaching from the Leaving Certificate science syllabi, contrary to the Transition Year guidelines. [4]

Throughout second level students can become engaged in the enquiry-based approach to chemistry and other sciences by participating in events like the BT Young Scientist competition, SciFest, Salters Festivals of Chemistry and other local initiatives. These are usually well-supported by industry.



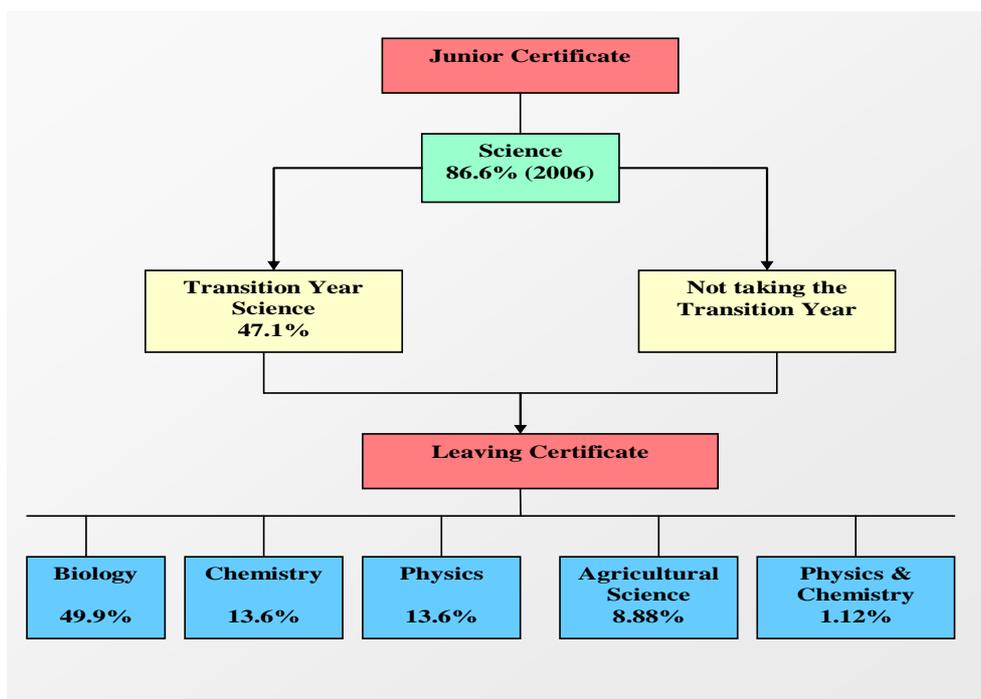


Figure 2: Secondary School Science in Ireland

2.2 Chemistry in Upper Secondary School

The next level is Leaving Certificate and as table 1 shows there is a relatively poor uptake of Chemistry at that level. The Leaving Certificate is also typically offered at two levels, Ordinary (OL) and Higher (HL), and the portion studying each level is also outlined in the table.

Levels Year	Total no of Chemistry Candidates	Percentage of total number of Leaving Certificate candidates	Number of OL Candidates	Number of HL Candidates	Percentage OL Candidates	Percentage HL Candidates
2006	7072	13.9	1358	5714	19.2	80.8
2007	6927	13.6	1197	5730	17.3	82.7
2008	7112	13.6	1210	5902	17.0	83.0
2009	7403	14.0	1366	6037	18.5	81.5
2010	7548	13.0	1251	6297	16.6	83.4
2011	7677	13.4	1405	6272	18.3	81.7

Table 1: Number of students studying Chemistry at Leaving Certificate

2.3 Reasons for Choosing to Study Chemistry Upper Second Level

Students might choose to study Chemistry out of general interest, or to meet the requirements for planned future study in domains like medicine or pharmacy (for which Higher Level Leaving Certificate Chemistry is a mandatory subject) or because of timetabling constraints which mean that they have no other option. In the former case this makes the subject attractive to high achievers, especially with typically more than twenty per





cent of students achieving an A grade at Higher level. In the latter case, the role of the teacher in engaging the student with the subject is particularly important.

The difficulty for the teacher, particularly where the students are not in the Chemistry class by choice so much as by default, is in the general perception of Chemistry as a subject: It is abstract, full of concepts which are commonly a source of misconceptions for both inadequately prepared teachers and for the students. In Ireland, it has been found that approximately 17.7% of Leaving Certificate Chemistry students have reached the formal operational stage of cognitive development that is necessary to cope with abstract concepts. [5]

The Chief Examiner for Chemistry has commented that there are participation issues: the candidature is dominated by Higher Level. He has also highlighted issues related to standard at levels, subject content, and delivery methods. His analysis points to a number of difficulties with the subject which must be overcome, including the fact that it is abstract, logical, requires some mathematics, needs clarity and accuracy, and that success requires engagement at higher cognitive levels. He also notes the increasing phenomenon that at ordinary level many candidates are presenting who are unprepared. [6]

3. The Role of the Educator

3.1 Training of Teachers

Science graduates going into teaching have traditionally been sought after, and have a strong chance of securing full-time employment. There are two ways of training to become a teacher in Ireland: either by completing the one year Post-Graduate Diploma in Education after successfully completing a primary degree with relevant course content, or by completing a primary degree which specialises in a particular subject as well as teaching skills. Given the options available it is a concern that one survey has shown that within the Science teaching cohort in Second Level schools, only 29% of teachers has Chemistry to degree level. [7]

3.2 Continuous Professional Development

The Minister for Education has initiated a number of reforms in the education system, including giving more power to The Teaching Council, to effectively 'licence' teachers, with membership being dependant on evidence of Continuous Professional Development (CPD) [8] Chemistry teachers have been supported for some time by the Second Level Support Service, which is now under the umbrella of The Professional Development Service for Teachers. This offers induction and continuous development training at a local and national level

iChemistry website

Irish CPD website

- resources include:
 - Updated PowerPoint presentations with embedded Numeracy and Literacy suggestions,
 - Past LC Exams and Solutions,
 - DARTS in various topics,
 - Flash Animations,
 - Images,
 - Video clips for each of the sections in the Chemistry syllabus,
 - BBC programs: History of the Atom (3 episodes) and History of Periodic Table (3 episodes),
 - Transition Year material,
 - Practical Videos,
 - Flash cards for Mobile phones,
 - Sample lesson Plans.

Presented at workshops organised in partnership with the Education Centres and with the local branches of the ISTA.

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Figure 3: The *iChemistry* CPD website





4. Curriculum Reform

Currently Chemistry is examined at two levels, Higher and Ordinary. Each syllabus has a list of twenty eight mandatory experiments, but while student's lab books may be inspected, practical work is assessed through compulsory questions on practical work. The final grade depends on being assessed only by written papers with no marks for coursework. [9]

The proposed new syllabus, which has been through a consultation process, will see the introduction of a practical component in the assessment procedures. Completion of mandatory practical throughout the two years of study will be worth 5% and students will take a 90 minute practical test worth 15%. The latter will involve completion of a series of three or four short set tasks, assessing practical skills and ability to analyse data and draw conclusions. A final component will be a written exam worth 80%. [10]

Interestingly, the syllabus document includes this preamble, *the syllabus is designed for all learners; the skills developed will form part of their lifelong learning and prepare them both for the workplace or for further studies in chemistry.* Perhaps at last an attempt to sell Chemistry for Chemistry's sake. The proposal to give value to practical work suggests that the new syllabus will be more 'active' for the students but there are a number of issues which are summarised by reaction of the teachers to the consultation information through their representative association, the Irish Science Teachers' Association (ISTA). [11]

4.1 Teacher reaction to proposed reform

The teacher reaction can be summarised as follows:

- Length of the syllabus proposed & guidelines as to depth of treatment – the syllabus is too long.
- Views on content added, omitted & deleted. Some worry about retention of what the teachers view as less relevant sections.
- Laboratory resources issues.
- Laboratory availability, management issues & IT resources
- In-service requirements
- Second mode of assessment issues.
- Terminal examination issues.

Particular areas of concern include topics and resources which could be solved by commitment to CPD and IT upskilling. Teachers are only too aware of the need to utilise Information and Communications Technology (ICT) to enhance the visualisation and computation needed for Mathematics and Science subjects. Research has shown a positive correlation between the use of ICT and academic performance. The reported benefits are gains in student achievement, increased student motivation, improvements in students higher order thinking and problem solving abilities and the development of students ability to work collaboratively.[12]

5. Other Supports and Issues

5.1 Other supports for professional development

There is a community of practitioners in Ireland who are providing excellent support to science teaching in general or chemistry teaching in particular. Young teachers are encouraged to access these facilities which are outside the realm of formal CPD but which are available for career-long support. They include:

- Irish Science Teachers Association (ISTA) [13]
- Chemistry Education Research Groups at third level [14]
- National Centre for Excellence in Maths and Science Teaching & Learning (NCE-MSTL) [15]
- Chemistry in Action! Magazine [16]
- Schools Information Centre on the Irish Chemical Industry (SICICI) [17]
- ChemEd-Ireland annual conference [18]

5.2 Issues to be addressed

There are a number of focus points to improve the uptake of Chemistry and science in school, but the main issue will be government commitment, needless to say financially, to resourcing the subject provision to meet twenty-first century demands: a major concern would be provision of technical assistance in schools and equally important would be a coherent programme of career-long, continuing professional development (CPD).





About 20 schools in Ireland out of 720 have technical assistance, and although there is in-service provision and support when a new syllabus is introduced (a major improvement on the past), this is cut back after a few years. [19]

The past and current situation is unsustainable and although the efforts to promote science through Science Week Ireland, the Discover Science and Engineering Programme, and other initiatives, are engaging and valuable they cannot replace investment in initiatives that will help the people working at the coalface. At a time of curriculum reform it is not enough to put words on paper. If the new syllabus is to turn the image of Chemistry around it needs to be backed up with practical supports including ICT up-skilling and resources.

- [1] Reville, W., (2010) Thirty Years of Science Communication and Popularisation in Ireland, *Chemistry in Action!*, Limerick
- [2] Technology Foresight Ireland, Report of the Chemical and Pharmaceuticals Panel, ICSTI, Dublin
- [3] Science Education in Europe: National Policies, Practices and Research (2011) Eurydice, Brussels
- [4] Hayes, S. (2010) A Critical Evaluation of the Place of Science in the Irish Transition Year and its Effect on Subject Choice for the Leaving Certificate, NCE-MSTL, Limerick
- [5] Childs, P. and Sheehan, M. (2009) 'What's difficult about chemistry? An Irish perspective' *Chemical Education Research and Practice*, 10, 204
- [6] Desmond, T. (2011) Observations of the Chief Examiner for Chemistry, ChemEd-Ireland conference October 2011.
- [7] National Association of Principals and Deputy Principals (NAPD) quoted in Oireachtas Library & Research Service (2009), Science and Maths Education in Ireland: Provision, Participation and Achievement
- [8] The Teaching Council (2011) Draft Policy on the Continuum of Teacher Education, Dublin
- [9] National Council for Curriculum and Assessment (NCCA) (2006) Chemistry Leaving Certificate Syllabus with handbook at <http://chemistry.slss.ie/resources/c/2946/1/Chemistry.pdf>
- [10] National Council for Curriculum and Assessment (NCCA) (2011) Draft Proposed New Chemistry Leaving Certificate Syllabus
- [11] Consultation Report ISTA (2011) www.ista.ie/system/files/ChemistryConsultationReport.doc
- [12] Engineers Ireland (2010) Report of the task Force on Science and Mathematics Education at Second level, Dublin
- [13] Irish Science Teachers Association (ISTA) www.ista.ie
- [14] Chemistry Education Research Groups at third level – while these largely focus on third level, issues but also have second level links.
- [15] National Centre for Excellence in Maths and Science Teaching & Learning (NCE-MSTL) www.nce-mstl.ie
- [16] Chemistry in Action! Magazine – produced three times annually, subscription rates from Peter.Childs@ul.ie
- [17] Schools Information Centre on the Irish Chemical Industry (SICICI) with resources for Transition Year. Contact Marie.Walsh@lit.ie
- [18] ChemEd-Ireland annual conference – one-day annually in October contact Peter.Childs@ul.ie
- [19] Childs, P.E., (2007) SMEC Keynote speech, Dublin

