

Motivating Students to Study Chemistry: Some Irish Initiatives

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In recent years, several initiatives have been taken to motivate more students to study Science in general and Chemistry in particular. Industrial and governmental bodies have spoken repeatedly about the need for skill-building in the Science Technology Engineering and Mathematics (STEM) subjects, including Chemistry, that are seen as vital in underpinning the Knowledge Economy and aiding Ireland's recovery from economic downturn.

Uptake of Chemistry as a subject for the terminal examination at second level in Ireland, the Leaving Certificate, has seen a slight increase to over fourteen per cent. However, this turnaround could be difficult to maintain due to a number of factors, not least the fiscal situation and its effect on school budgets for more expensive practical subjects, as well as allocation of subjects to students within timetabling constraints and choice by students of the science and technology subjects. The latter is further influenced by attitudes to, experiences of and perceived usefulness of Chemistry, both by students and their guardians. Teachers and school facilities have a central role to play in student motivation. A proposed new curriculum for second level Chemistry, with a more emphatic requirement for practical work, is currently in the post-consultation phase, and a new Chief Examiner for Chemistry at upper secondary level has recently been appointed.

This paper will present a review of the current status in Ireland for motivating more students to study Chemistry, and more teachers to keep apace of the changes in Chemical Education and Information and Communication Technologies which have become best practice internationally.

1. Introduction

Ireland's status regarding student motivation (or lack of same) to study Chemistry is not unique. Network sharing of experiences has shown that across Europe and beyond similar problems with attracting students to study or value Chemistry exist. Attempts to qualify issues around motivation may start from a general perspective before focusing more specifically on Chemistry.

Attempts to analyse student motivations toward learning have distinguished between what students want and what motivates students in the classroom, concluding that an important factor is whether students care about or think the task is important in some way. [1]

Recent studies have considered the generation and maintenance of interest in Science as a motivational factor. [2] Science and Chemistry education in Ireland has been hailed as a potential route to lifting the country out of economic gloom. However, the reality of living within budgetary restraints and cutbacks has compromised the ability of schools to provide the subjects at a practical level. Common sense tells us that the transition from the 'magic' of Science as an investigative, inquiry-based curriculum at primary and lower secondary level to the theory-laden subjects that have been characteristic of upper secondary level can only be de-motivating for some students. However, pedagogical constructs can elevate science education to provide a solid foundation for lifelong learning, within the limits of the students' motivation to learn science. [3] Caldwell has suggested that use of a questionnaire to measure student motivation might help teachers assess the student's attitude towards learning in the science classroom. [4] His proposed questionnaire items include: attitude toward doing science, perceptions of one's peers (subjective norm), perceived ability to do science and intention.

2012 has seen a slight positive turn-around, perhaps as a result of a number of initiatives over recent years to promote Science, Technology, Engineering and Mathematics (STEM) subjects in Ireland, in the numbers of



students studying Chemistry as a Leaving Certificate subject, with 14.5% of the Leaving Certificate cohort opting to study the subject.

The poor uptake of science and mathematics at second level has in the past fed on into third level. The number of students applying for third level STEM places increased in 2012, provoking this response from Dr. Graham Love, Director of Discover Science and Engineering: *“Today’s students are very savvy and are taking into consideration the areas where the best career opportunities lie. It is encouraging to see the higher uptake of students who have been offered and will undertake technology and science courses this year. There is a growing demand for graduates in these areas as they continue to thrive in Ireland and working in these industries offers graduates vast and exciting opportunities.”* [5]

Perhaps this is a response to initiatives like the Chemical and Pharmaceutical industry’s *Hearts and Minds*, a strategy to ensure wide appreciation of the benefits the sector brings to Ireland.[6] This recommends that at first and second level, the education system should aim to: 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. The strategy failed to address the lifelong learning aspect of appreciating Chemistry as a worthwhile subject in its own right.

2 Chemistry in the Irish Education System

2.1 Chemistry in Primary School Science

Chemistry is embedded in the Primary curriculum in a stream of Social Environmental and Scientific Education, which was formally introduced in 2003/4. The curriculum is presented in two sections: a skills section and a content section. The skills section supports children in working scientifically and in developing their designing and making skills, encouraging them to learn by investigating: observing, asking questions, suggesting explanations, predicting outcomes, planning investigations or experiments to test ideas and drawing conclusions. Designing and making is the technological component of the Science Curriculum, which provides children with opportunities to apply scientific ideas to everyday situations and problems. Chemistry is implicit in the *Materials* and *Environmental Awareness and Care* strands.

2.2 Chemistry in Lower Secondary School Science

Science at lower secondary level is presented as a single Junior Certificate subject with three distinct sections, one of which is Chemistry. 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. [7]

In October 2012 the Minister for Education unveiled plans that will see students at the centre of the new approach to assessment. Schools will be expected to deliver a programme that will enable students to develop a wide range of skills, including critical thinking skills and basic skills such as numeracy and literacy. They will also be encouraged to value the role and contribution of science and technology to society, and their personal, social and global importance and to use appropriate technologies in meeting a design challenge. The existing science and technology suite of subjects will be retained but will be updated to reflect the new programme. Inquiry-based learning will underpin elements of the coursework.

From 2016 standardised testing in Science will also be included for all students to provide a clear indication of the student’s progress in the middle of the junior cycle programme. As we enter this new phase for our education system we should look to lessons from past curriculum reforms. One study has looked at students’ experiences of science in the first year of post-primary school and its findings revealed broadly positive attitudes towards post-primary school science, especially the experimental work that is at the heart of the curriculum. However, it would appear that students were not conducting open-ended investigations or using information and communications technology (ICT) to any great extent; moreover, there was some evidence of traditional didactic teaching methods being utilised. [8]

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 usually in the form of short modules with attractive titles, e.g. Cosmetic Science and Forensic Science, where



students learn Chemistry without realising what it is! Few teachers have laboratory time for all of their science classes during Transition Year. [9]

2.3 Chemistry in Upper Secondary School – in reform status

ISCED3 in Ireland is 'Leaving Certificate' and there is a relatively poor uptake of Chemistry at that level. In 2012 approximately 14.5% of the candidature sat the Leaving Certificate examinations in Chemistry. The Leaving Certificate is offered at two levels, Ordinary (OL) and Higher (HL), which creates a difficulty in classroom management as both levels are typically taught in the same classes. However, there is anecdotal and statistical evidence that Chemistry students have a higher chance of gaining an A grade at Higher level, with approximately 20% receiving this grade annually. This makes the subject attractive for students aiming for high points for third level. This is counterbalanced by a failure rate of 9% at HL and 16% at OL.

A new draft Chemistry syllabus has passed through an extensive consultation phase and is now being prepared for roll-out. The proposed new syllabus 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 there is an attempt to sell Chemistry for Chemistry's sake. Contextualising the subject in this manner may play an important motivational role for potential future students. The transferable skills gained from practical activities and report-writing may also add to the perceived value of the subject.

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 highlighted by teachers through their representative association, the Irish Science Teachers' Association (ISTA). 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. [11] Feedback from participants at the *Chemistry Is All Around Network (CIAAN)* workshop in Limerick Institute of Technology (LIT) in September 2012 was that many of the resources collected for the project portal could be very beneficial from this point of view.

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 Leaving Certificate Chemistry HL is a mandatory subject) or because of timetabling constraints which mean that they have no other option. In the latter case, the role of the teacher in engaging the student with the subject is particularly important. Discussions at the CIAAN workshop in LIT in September 2012 mentioned the importance of the teacher as a motivational role model.

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. [12]

3. The Role of the Educator

3.1 Training of Teachers

Teachers are the gatekeepers for the future generations of scientists and engineers, two key players in the knowledge economy. Science graduates going into teaching have traditionally been sought after, and have a



strong chance of securing full-time employment. Science is a subject that is constantly changing and evolving. If teachers are unable to appreciate and adapt to this, their students may be left with an unrealistic view and understanding of the value and use of science in our everyday lives. [13]

3.2 Continuous Professional Development

Chemistry teachers have been supported for some time by the Second Level Support Service (SLSS), which is now under the umbrella of The Professional Development Service for Teachers (PDST). This offers induction and continuous development training at a local and national level. *iChemistry* is a web-based resource portal which was also made available to in-service training sessions in CD-rom format.

3.3 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) [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]

3.4 Technical issues

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. 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. 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.

3.5 National availability of ICT resources to teach chemistry

The participants at the CIAAN meeting were given the list of twenty five resources uploaded by LIT to the project portal. Most were familiar with some, but not all, of these resources. Many expressed the opinion that they would now use these resources in school as some of them had obvious links to various stages of the Irish curriculum. Others would be relevant to the Irish Transition Year, which is not bound by an exam syllabus. All agreed that the quality of national materials is improving, and that mapping to the national curriculum is an advantage.

The teachers were most attracted to the visual, interactive content on websites. They also appreciated resources that they could use in class, via interactive whiteboards and other supports, but also direct the students to for additional work at home.

4 Motivating students to motivate themselves: Public Understanding of Science Programmes

Discover Science & Engineering (DSE) is Ireland's national science promotion programme, managed by Science Foundation Ireland on behalf of the Department of Jobs, Enterprise and Innovation. The objective of DSE is to bring together all existing awareness activities and expand these in a way that will eliminate



duplication and provide a more focused and effective communications strategy. It aims to increase interest in science, technology, engineering and mathematics (STEM) among students, teachers and members of the public, to contribute to Ireland's continued growth and development as a society – one that has an active and informed interest and involvement in STEM. Its activities include web resources, a careers portal, science ambassadors and active programmes like Discover Primary Science and Maths. [20]

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, as are countless local initiatives like workshops, science magic shows, interactive lectures and industrial visits.

Science Week is promoted annually in November and attempts to engage all sectors in appreciation and understanding the importance of science. The theme for 2012 is 'Everyday Experimenting' and perhaps that will motivate or inspire some students towards Chemistry. [21]

In spite of these diversions from the regular curriculum there is no doubt that the teacher remains a primary actor in motivating students to choose to study Chemistry: no less than any other subject. '*Student motivation is an essential element that is necessary for quality education. How do we know when students are motivated? They pay attention, they begin working on tasks immediately, they ask questions and volunteer answers, and they appear to be happy and eager.*' [22] The CIAAN project has identified some valuable sources of ICT-based materials to support chemistry teaching and learning on both a formal and informal basis. [23]

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- [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 2013 Marie.Walsh@lit.ie
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