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Students' Motivation to Learn Chemistry in Ireland



Lifelong
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Students' Motivation to Learn Chemistry in Ireland

Marie Walsh

Limerick Institute of Technology, (Republic Of Ireland)

Marie.Walsh@lit.ie

Abstract

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 report will present a review of the current status in Ireland for motivating more students to study Chemistry, and more teachers to keep pace 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. Students apply for third level places based on a points system and the points for science and mathematics courses had dropped considerably. Even more alarmingly, dropout rates of up to 39% have been reported recently for some university science courses.[5] 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.

Encouragingly, 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."* [6]

Perhaps this is finally 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.[7] 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 to some extent 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

The structure of the Irish education system is shown in Figure 1, with some indicators of the role of Science/Chemistry.

Chemistry is embedded in the Primary curriculum in a stream of Social Environmental and Scientific Education, which was formally introduced in 2003/4. [8] 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.

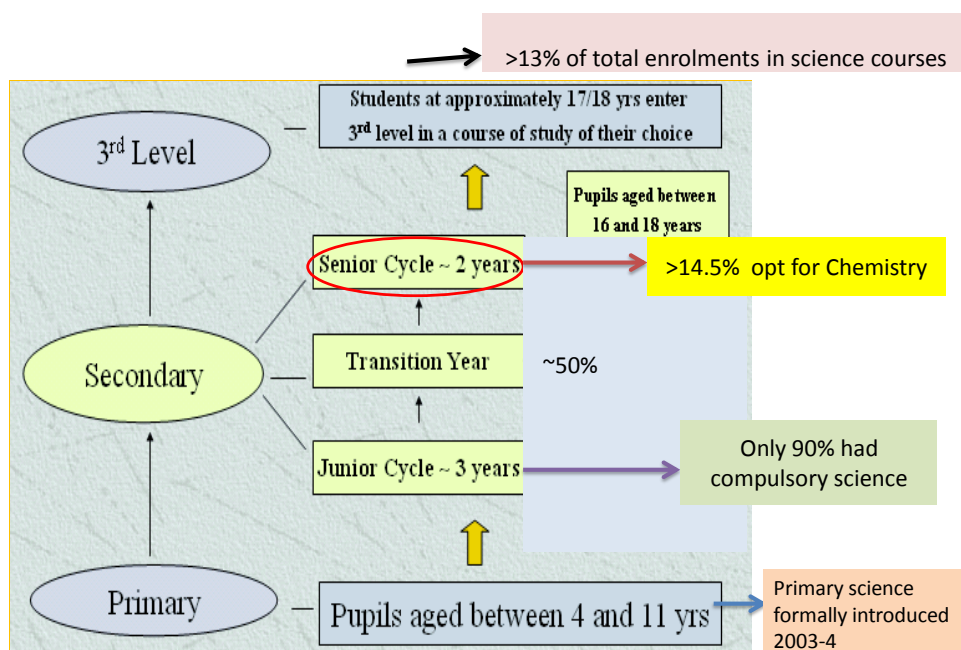


Figure 1: The Irish Education System and Science/Chemistry

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. [9] Table 1 outlines the current status of Junior cycle Science subjects, with the proviso that these are in a state of chassis due to on-going reform. [10]

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.

Level	Subject	Assessment		
Junior Certificate At Higher and Ordinary levels	Science (revised syllabus)	Coursework A 30 mandatory experiments: 10 each from Chemistry, Physics, Biology Marks: 10%	Coursework B 2 out of choice of 3 mandatory investigations, one each from Chemistry, Physics, Biology Marks 25%	Terminal written examination Section A: Biology Section B: Chemistry Section C: Physics Marks 65%

Table 1: Secondary School Junior Science in Ireland

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. [11]

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. 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. [12]

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, which will be discussed later. These are usually well-supported by industry.

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%. [13]

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 Continuous Professional Development 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. [14] 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 Higher Level 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. [15]

2.4 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. [16]

2.5 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). [17] 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.

2.6 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) [18]

National Centre for Excellence in Maths and Science Teaching & Learning (NCE-MSTL) [19]

Chemistry in Action! Magazine [20]

Schools Information Centre on the Irish Chemical Industry (SICICI) [21]

ChemEd-Ireland annual conference [22]

2.7 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. [23]

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.

2.8 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.

3 Setting up the Network in Ireland

3.1 Limerick Institute of Technology as main Irish partner

The Department of Applied Science at Limerick Institute of Technology (LIT) [24] offers programmes ranging from Higher Certificate (Level 6), Ordinary Degree (Level 7) and Honours Degree (Level 8) to Taught Masters (Level 9) in a variety of Science disciplines. These include Applied Biology, Applied Chemistry and Environmental Science, in addition to Pharmaceuticals, Forensics and Drug Analysis. There are currently c.360 students studying across the range of undergraduate and postgraduate programmes in the Department. It also has several postgraduate research students working on research at Masters and Ph.D. level, many of them studying topics with Chemistry at their core.

LIT Science graduates can be found working in a range of roles in the private sector, including: food, pharmaceutical, health care, private analyst laboratories, and biotechnology; and the Public Sector in state laboratories, forensic labs, local authorities, schools and colleges, environmental and health agencies. The courses in Applied Chemistry and Applied Biology can lead to level 8 Honours qualifications which are recognised by the Teachers' Council of Ireland for postgraduate training for science education. A number of graduates have chosen this career path rather than industrial employment.

The Department is renowned for its excellence, from teaching staff to state-of-the-art equipment and laboratories. The programmes have a reputation for quality, particularly among industrial employers and we are continuously updating programmes to meet the demands of modern science-based industries. Students spend a large amount of time in the labs, putting theory learned into practice.

The oldest course in the Department of Applied Science is the Higher Certificate in Applied Chemistry (level 6) which is the stepping stone to a level 7 and then level 8 degree. The latter is approved by the Teaching Council of Ireland for Postgraduate training in secondary level Chemistry education. Some full-time science staff members have a background in Science Education which they maintain as one of their primary interests within the teaching programmes. The Department also retains close links with the regional branch of the Irish Science Teachers' Association [18] and has an outreach office of the National Centre for Excellence in Mathematics and Science Teaching and Learning. [19] It supports science education and promotion activities through workshops, conferences, exhibitions, lectures and a number of other outreach activities.

Although Chemistry is a common subject for all first year undergraduates in LIT science programmes, less than one-fifth of these may have studied Chemistry at senior secondary (Leaving Certificate) level. This is in line with the national trends as shown in Table 2.

Year	Total no of Chemistry Candidates	Percentage of total number of Leaving Certificate candidates
2006	7072	13.9
2007	6927	13.6
2008	7112	13.6
2009	7403	14.0
2010	7548	13.0
2011	7677	13.4
2012	8086	14.6

Table 2: Chemistry candidates at Leaving Certificate as percentage of total candidature

Participation in the Chemistry Is All Around Us Network Project is compatible with LIT's efforts to promote Chemistry as a subject integral to third level undergraduate science programmes, as well as its commitment to support second level Chemistry teachers and students.

3.3 Selection of Manager of project in LIT

Marie Walsh has over thirty years of experience of teaching Chemistry and other life science subjects at second and third level. She has also taught modules in 'Science for non-Scientists' as well as working as a Research Assistant in the University of Limerick for a lecturer in Science Education. The latter involves collecting and collating information on Chemistry education to disseminate to teachers, some of this through Chemistry in Action! – a magazine produced three times each year and distributed to over seven hundred Irish teachers of Chemistry, as well as subscribers from overseas. She is the LIT representative on the committee of the local branch of the Irish Science Teachers' Association (ISTA) and the college's co-ordinator of SciFest [25], a science fair for secondary school students, and of the activities for Science Week [26]. She is a member of the international advisory board of i5 Teaching Network [27]. She has been an Advising examiner for Junior Certificate Science for a number of years, a role that is key to the quality and fairness of the examinations process. She is also a member of the national committee for Eurachem Analytical Skills Measurements competitions, and co-ordinates and trains the LIT teams for the national competition that takes place each Spring. Her participation in the Chemistry is All Around Us Network project is a natural extension of her existing activities in promotion of Chemistry.

3.4 Recruitment of the Irish network members

The portal users can be divided into three groups, Teachers, Students and Experts. The recruitment methodology was to advertise the project and the need for volunteers in the first instance through the local branch of the ISTA and then through email lists of contacts compiled over a number of years as a result of workshops, conferences and other activities. The basic premise was that anyone who participates in out-of-school activities like workshops, conferences or ISTA branch meetings would be more inclined to volunteer to participate in the project. Likewise, the Experts were drawn from colleagues encountered through conferences, committees and other activities, with a proven record and interest in School-College links.

3.5 Effectiveness of the recruiting strategy

Interest in the project was evident from the speed with which ten teachers and five experts were recruited. Two of the original teachers subsequently withdrew, for personal reasons which meant they could not commit fully to the project, and were replaced by others who had been on a 'reserve list'. The recruiting strategy has been validated by the participation of the teachers and experts to date.

3.6 Schools who have committed to the project

In total eight schools agreed to become involved, with a mixture of different typologies as outlined in Table 3. One of the schools is a National School, which is the Irish terminology for Primary school. The other seven are Secondary Level schools. A Gaelcholaiste is a school where the students are taught and take examinations through the medium of Irish language. All other schools participating teach through the English language medium. A Secondary school typically offers a more academic range of subjects, while a Community School offers a mixture of academic and vocational subjects. Science lies on the interface between academic and technical subjects but at Leaving Certificate level Chemistry and Physics in particular have been dropped by a number of schools because of financial and resource issues.

The first instinct was to recruit schools nearby Limerick Institute of Technology to provide ease of access for travelling to meetings. However, by widening the recruitment net the project now has a good mix of urban and rural schools and therefore a wider population for the next phases of the project.

Name of School/Teachers	Level of School	Gender	Age group	Number of Teachers involved	Number of Students involved
Castleconnell National School Brian Dillon & Grace Kenny	National School (Primary)	Mixed	5 - 12	2	40
Ard Scoil Ris Limerick Diane Condon & Rose Lawlor	Secondary	Boys	12 - 18	2	40
Gaelcholáiste Luimnigh Ciara NiDhrisceal	Irish language Secondary (Gaelcholaiste)	Mixed	12 - 18	1	20
Hazelwood College Michelle Herbert	Secondary	Mixed	12 - 18	1	20
St Attracta's Community School Sligo Ciara O'Shea	Secondary	Mixed	12 - 18	1	20
St Caimins Community School Shannon Maria Sheehan	Secondary	Mixed	12 - 18	1	20
St Joseph's Spanish Point Clare Angela Gammell	Secondary	Mixed	12 - 18	1	20
Tallaght Community School Dublin Mairead Glynn	Secondary	Mixed	12 - 18	1	20

Table 3: Schools involved as partners to LIT

The locations of the participant schools are indicated on the map below:

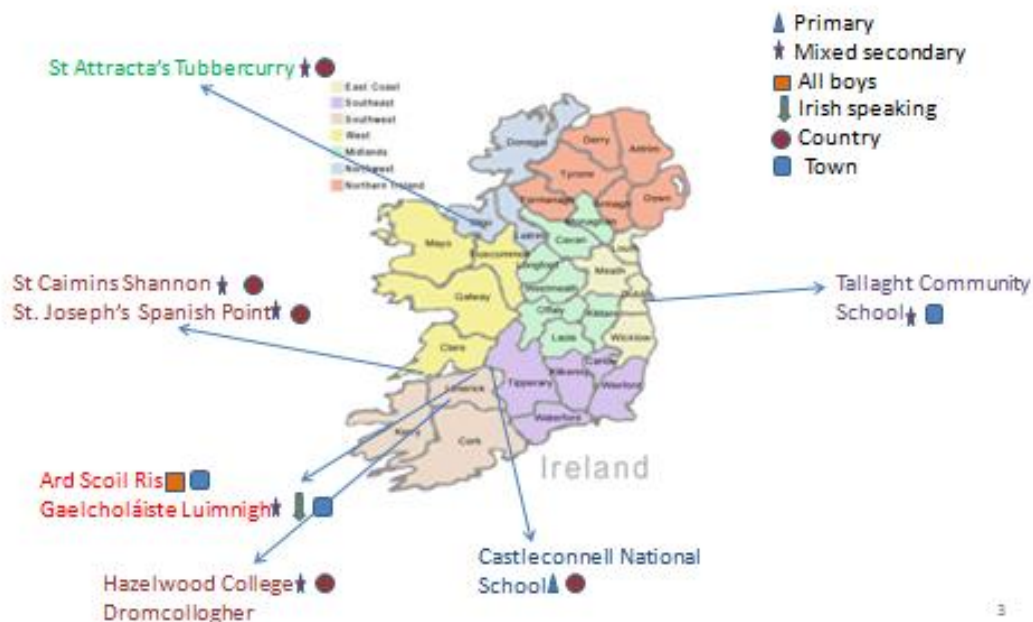


Figure 2: Locations and typologies of the Irish partner schools

3.6 Experts who committed to the project

In total five experts agreed to become involved, with a mixture of different typologies as outlined in Table 4.

Name of Expert	Affiliation	Experience relevant to Chemistry Is Network Project
James Ring	Limerick Civic Trust	Formerly Education Executive for Pharmaceutical Ireland [28]
Michelle Starr	National Centre for Excellence in Maths & Science Teaching & Learning [19]	Liaison officer in support of education-industry links
Claire McDonnell	Dublin Institute of Technology [29]	Lecturer with particular interest in Chemistry Education
Kathleen Lough	Galway-Mayo Institute of Technology [30]	Lecturer with interest in outreach activities
David Sutton	Limerick Institute of Technology	Environmental & Analytical Chemist with interest in science promotion

Table 4: LIT partner experts

Irish Network Experts

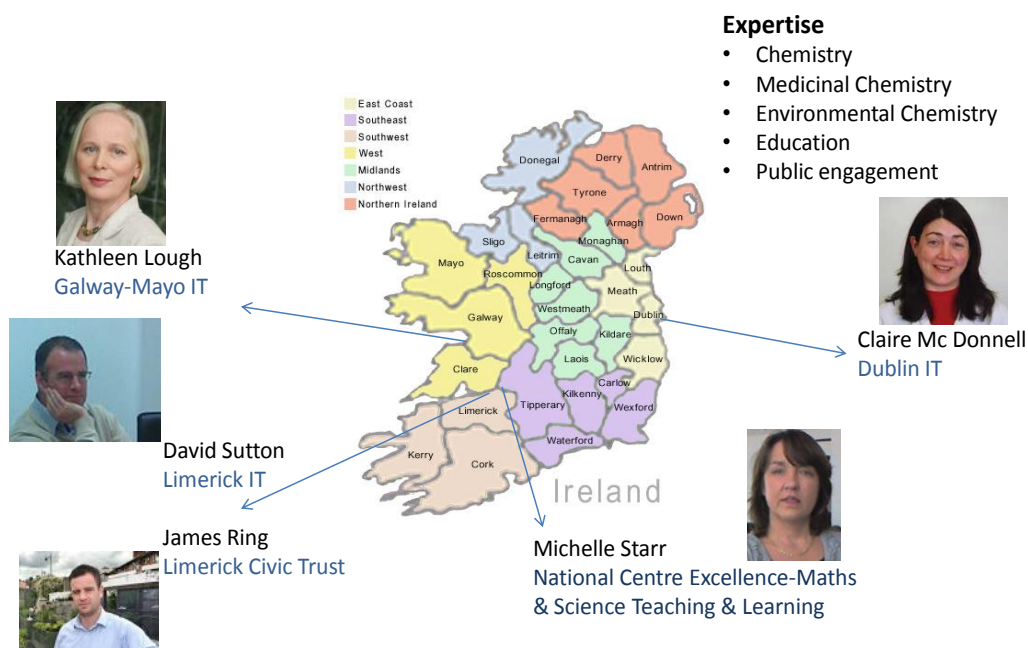


Figure 3: Irish network experts

David Sutton was chosen as someone who works in LIT and therefore could act as a substitute in the event of Marie Walsh being unable to participate in the project. James Ring is an Environmental Chemist also located in Limerick, but his wider experience in liaison with industry through his role as Education Executive with Pharmaceutical Ireland [28] is invaluable. Pharmaceutical Ireland is the industry

representative organisation for pharmaceutical and fine chemicals manufacturers in Ireland. As this sector accounts for approximately fifty per cent of the country's Gross Domestic Product it is economically vital and is also supportive of educational initiatives to promote STEM teaching and learning.

The National Centre for Excellence in Maths and Science Teaching and Learning [19] is based at the University of Limerick. Michelle Starr is the Centre's liaison officer and works at the interface of industry, research and education. Kathleen Lough and Claire McDonnell are lecturers and researchers at Institutes of Technology. Claire in particular is interested in Chemistry education and is part of the Chemistry Education Research group at Dublin Institute of Technology. In 2009 she was awarded the Royal Society of Chemistry Higher Education Teaching Award and also a Teaching Excellence award from the National Academy for Integration of Research, Teaching and Learning along with 3 colleagues.

The experts again are representative of different geographical regions in Ireland but their individual interests and combined experiences are an asset to the project team.

4. Main obstacles to Students' Motivation to learn Chemistry

4.1 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. [31]

The former 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 noted the increasing phenomenon that at ordinary level many candidates are presenting who are unprepared. [32]

4.2 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 Science Week and Discover Primary Science [33]

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.

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.' [34] 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. [35]

5. Analysis of Teaching Resources

Extensive research to identify Irish materials was carried out and as a result Limerick Institute of Technology uploaded 25 links, 16 from Irish producers and a further 9 from UK and US sources. Full reference links to these and reviews can be found on the CIAAN Project Portal.

5.1 LIT uploaded Resources: Primary level

- Discover Primary Science Activities
- Chemistry for Juniors - Sci-spy
- 50 really cool online tools for science teachers
- Chemistry Chaos - Planet Science
- Chemistry at Steve Spangler Science

5.2 LIT uploaded Resources: Secondary level

- iChemistry
- Chemistry and water treatment
- Chemistry for Junior Certificate - Science Unleashed
- Chemistry for Junior Certificate Science
- Chemistry in Action!
- Chemistry Stimulus To Engage – Discover Sensors
- Chemistry Support Service
- Clean Water
- Medicines and You
- Nano in my life
- Pharmaceutical Ireland - Cosmetics Module
- Virtual Chemistry Laboratory for Irish Post-Primary Schools (VCLIPPS)
- World of Chemistry
- Chemistry at Steve Spangler Science
- Teaching Chemistry
- The Periodic Table of Videos
- Learn Chemistry

5.3 LIT uploaded Resources: Tertiary level

- CERP - Chemistry Education Research and Practice
- CHEMNET
- Learn Chemistry****
- Professor Dave's Amazing Molecules

5.4 Teacher comments on national and non-national resources

The Irish teachers agreed on a number of points and these comments were echoed for both the national and non-national items which they reviewed. In the first place the quality of national materials has shown continuous improvement. Mapping to the national curriculum is an advantage, whereas some of the non-national items did not fit as clearly into the expectations regarding education level or age appropriateness. In general, the teachers liked resources that could be used with interactive whiteboards and other supports. They also saw a great benefit to having resources which could be used by students for additional work at home. Teachers were most attracted to the visual, interactive content on websites. One significant drawback was seen to be lack of appropriate primary material. It was also unfortunate that some of materials that appeared very useful were only available in the native language and that translation was difficult or not available for some. More information on these comments is included in Section 6 (below).

The teachers from other countries commented on several of the resources uploaded by LIT. While much of the comment was favourable, there were also some points worth consideration. Like the Irish teachers they appreciated clear age or education level and interactive content. One other valid point was that some of the uploads were to web portals rather than compact teaching packages, and that there was just too much content in these.

5.5 Top selections from other countries

It was noted that many of the non-national selections were US or UK based. The items listed below were singled out as appropriate for trialling in Irish schools, and indeed some of the teachers were already using them.

- Materials for special uses
- General Chemistry on Line from University of Dartmouth
- Science Kids
- A Química das coisas (The Chemistry of Things)
- An Introduction to Chemistry by Mark Bishop
- Chemistry for Life

Full links to and reviews of these are available on the CIAAN Portal. All are available in English or with English subtitles.

6. Workshops

6.1 Introductory Workshop

In March 2012 an introductory meeting was held to explain face-to-face what would be involved in the project for potential volunteers. Ten people attended and eight of these remained with the project.

A powerpoint presentation outlining the project and the role and remit of the teacher participants was delivered. The teachers were also given an information pack and shown the requirements for letters and forms from the schools. A question and answer session followed. Teachers confirmed interest in participating and prepared to consult their school principals with regard to the letter of participation and the form.

6.2 Portal Evaluation Workshop

In September 2012 the prescribed evaluation workshop was held in the Institute Boardroom LIT. Thirteen of the fifteen team members were present. The two who could not attend were briefed afterwards by telephone and email and completed all work required for the project.

The teachers and experts were welcomed to Limerick Institute of Technology and to the first meeting of the whole Irish team. The participants introduced themselves and their affiliations. As this was the first

meeting of the whole group the aims and objectives of the project were presented to the team by Marie Walsh.

The presentation outlined the development of the project and the members of the partnership. It reiterated the aims of the project and the different phases across the three years of the project's anticipated lifetime. The teachers and experts were also give some indication of the progress to date, and were provided with a list of the items uploaded onto the portal by Limerick Institute of Technology. Some clarification about the role of the teachers and experts was achieved. They were also briefed on the future activities of the partnership.

6.3 Presentation of teachers' and experts' comments about the papers and publications on Student's Motivation uploaded by Partners on the Project Portal

The participants who had chosen to comment on papers and publications on Student's Motivation spoke in turn about their perceptions of the material. These included materials posted on the portal from the partners in Spain, Bulgaria, Belgium, Portugal, Czech Republic, Turkey, Greece, Italy and Poland.

Each participant spoke about the paper and/or publication that they had reviewed. With regard to the papers, there was a disparity in length, quality and referencing between different papers. It was recommended that there be agreement among the partners about standardising the length, currency and detail in such papers. In addition each should be appropriately referenced. Some of the papers generated a lot of positive comment. Some of the publications were also inspiring in their reportage of well-conducted initiatives and research.

6.4 Presentation of teachers' and experts' comments about the teaching resources uploaded by Partners on the Project Portal

Most participants had chosen at least one Teaching Resource to review. They regularly expressed difficulty with choosing the items. Some had difficulty with translation of the partner reviews, and others were disappointed that while the review could be translated the actual resources couldn't all be translated.

As each participant took to the floor to show their chosen resources to the other teachers and experts, we were able to gain an impression of the various resources and form opinions about their useability, relevance to the Irish curriculum and general usefulness. As with the papers and publications there was an obvious disparity in quality and relevance. Some of the materials were out-of-date, with one website having a number of links of which about 70% do not work.

It was agreed that if the resources could be mapped to the curriculum their usefulness would become more apparent. It was acknowledged that some of the resources would be more applicable for chemistry/science promotion rather than teaching (especially within an exam-driven curriculum).

6.5 Discussion on the national availability of ICT resources to teach chemistry and science at different levels and on the difficulty of selecting suitable teaching resources

The participants were given the list of twenty five resources uploaded by Limerick Institute of Technology to the 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.

The proximity of Ireland to the UK means that a lot of material used here originates in the UK. Even the iChemistry professional development initiative for Irish chemistry teachers includes many links to UK-sourced materials.

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.

6.6 Identification of the most appropriate resource for each school level to be proposed to associated schools for a trial during the next school year

As the items were presented it became evident that some resources had engaged their reviewers more than others. The participants identified the following as being particularly attractive and potentially useful:

- X-Science – paper from University of Genoa: inspiring to link lessons to cinema.
- General Chemistry on Line from University of Dartmouth
- Materials for special uses – from Chemistry is All Around web portal
- Science Kids
- Chemistry of Things
- An Introduction to Chemistry by Mark Bishop
- Chemistry for Life

Disappointment was expressed about the lack of primary school materials.

6.7 Main conclusions of the workshop

The workshop was fruitful in that it allowed face-to-face discussion of the portal and progress to date, as well as sharing of experiences of the portal. It also led to informative evaluation of the material. The main results are as follows:

Publications were discussed at the workshop. Disparities were noted in length, quality and referencing. It was recommended that the partners agree and comply with a standard format.

Teaching Resources reviewed drew a number of comments:

- Quality of national materials improving: at the end of the workshop the selection of Irish materials was highlighted so that teachers could see any that they might not previously experienced.
- Liked resources that could use with interactive whiteboards and other supports.
- Useful when students could use for additional work at home.
- Lack of primary material.
- Teachers were most attracted to the visual, interactive content on websites.
- Translation difficulties – reviews/ actual sites
- Usability
- Relevance to the Irish curriculum
- General usefulness.
- Quality. Some of the materials were out-of-date, with one web portal having a number of links of which about 70% do not work.
- Mapping to the curriculum would be beneficial.
- Reorganising resources by level, discipline, etc.
- Some resources more applicable for promotion activities.

There was a lot of positive comment from the workshop participants and the majority felt the project had made a good start towards achieving its objectives. Some suggestions were made that might make the portal and the resources collected more appealing: Rank by age/level as well as by type, revamp the search engine and map to curricula wherever possible; make the portal more visually appealing and interactive, perhaps with screen-casting or podcasting from the portal itself.

6.8 Dissemination workshop

In October 2012 Marie Walsh was invited to deliver a thirty minute 'workshop' to introduce teachers attending the ChemEd-Ireland 2012 conference in Dublin City University. This conference takes place annually in October and is aimed at Secondary and third level teachers of Chemistry. The workshop ran four times in the middle of the conference in parallel with other workshops. A total of 65 teachers attended the sessions where they were introduced to the project via a presentation and then given time to browse the resources available and ask questions. The feedback from these sessions was very favourable and generated some interest in the project. Next year's ChemEd will take place in Limerick Institute of

Technology and it is anticipated that there will be a further platform for dissemination of the portal materials.

7. Conclusions

As this report indicates, the Irish network is now established and is at the phase of inviting Associated Partners and Schools. The participants in the Irish network have had fruitful discussions of their experiences and also of their use of the Project Portal. Virtual meeting with partners from other countries has indicated that issues around Student Motivation are echoed across Europe (and probably beyond). Chemistry is a valuable but for some an academically inaccessible subject. Provision of interactive, visually engaging and stimulating ICT-based materials may attract more students to the subject. It may also encourage teachers to think about how they present the subject to their students.

Ireland is in a state of curriculum reform across Science subjects and is in a position to react to research-based evidence that engagement using ICT is possible. The National Council for Curriculum and Assessment has clear policies with regard to the value of ICT in Education:

'ICT has become an integral and accepted part of everyday life for many people. ICT is increasing in importance in people's lives and it is expected that this trend will continue, to the extent that ICT literacy will become a functional requirement for people's work, social, and personal lives...

The use of ICT in appropriate contexts in education can add value in teaching and learning, by enhancing the effectiveness of learning, or by adding a dimension to learning that was not previously available. ICT may also be a significant motivational factor in students' learning, and can support students' engagement with collaborative learning.' [36]

To this end, the Chemistry is All Around Us Network project and its collection of Papers, Publications and Resources may encourage motivation of students, parents and teachers to engage with Science in general and Chemistry in particular.

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