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CHEMISTRY IS ALL AROUND NETWORK

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Teaching at the Heart of Learning: Successful Experiences and Good Practices in Chemistry Teaching in Ireland

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Abstract

Chemistry is all Around Us: our lives without Chemistry and the advances it has allowed in healthcare, hygiene, energy production, materials and technologies would be very different. In spite of this reality Chemistry as a school subject has suffered from negative perceptions, with even the word 'Chemical' inspiring negative reactions. It is also perceived as a mathematical and abstract subject, best-suited to only the most academically able students. However, these perceptions are a disservice to Chemistry and its value for society as a whole. From the earliest stages of education we can instill an appreciation of Chemistry for its own sake, that may or may not lead to more students studying Chemistry as a subject at second and third level, but that will at least redress the balance to a more favourable and positive perception of the value of Chemistry. Ask any scientist, engineer or technical professional about how and why they chose their career path and often they will tell about a special person who recognized, nurtured and encouraged their curiosity when they were younger. Most times this person will be an educator, a teacher or mentor, who has engaged through example: natural curiosity, innovative methods and a spirit of sharing with enthusiasm. Teaching is at the heart of learning, and learning to teach and to continuously self-reflect and update knowledge and pedagogical methods is vital. This paper surveys successful experiences and good practices in Chemistry teaching in Ireland, describing the importance of the initial teacher education and continuous professional development. It also underlines the importance of connecting Chemistry Education Research with Chemistry in the Classroom.

1.Introduction

'He who can, does. He who cannot, teaches'.[1] In the one hundred and ten years since George Bernard Shaw wrote these words, education systems have undergone changes that have seen the teaching profession become more highly regulated and more intrinsically connected to research into pedagogical styles. In the case of scientific subjects like Chemistry, the pace of discovery over the last one hundred and fifty years or so has meant that the subject content knowledge has changed dramatically and teachers have had to cope with new dimensions of subject knowledge in addition to new ways of disseminating that knowledge in the laboratory or the classroom. Acquiring a thorough knowledge of Chemistry is only part of the issue for a teacher – the other half of the challenge is to be able to transmit that extensive knowledge step by step in an empathetic manner, building it up in the minds of pupils into a logical, coherent and accessible rationale of the molecular character and reactivity of matter. Not all students will go on to further study of Chemistry, but in a positive teaching and learning environment they will gain knowledge about the value of Chemistry and transferable skills for their everyday lives. Others will use their foundation Chemistry studies in professions like Medicine, Dentistry and Pharmacy, and Chemistry is a core subject for many applied sciences, like Biotechnology or Forensics. Teaching is not for the faint-hearted, but extra effort in teaching Chemistry can engage, inspire and inform students and the public understanding of science (PUS) is all the better for it. Thus successful experiences and good practices are dependent on the Chemistry teachers challenging themselves as well as their students.

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Successful experiences and good practices can be dependent on a number of broad areas:

- Initial teacher education, with the correct balance between Subject Content Knowledge and Pedagogical Skills Training.
- Continuing personal development with adequate supports and relevant content.
- Making connections between chemical education research and chemistry in the classroom to inform innovation in teaching.
- Implementing appropriate Information Communication Technologies (ICTs) as an aid rather than a substitute.
- Networking and sharing of experiences.

1.1 Initial Teacher Education

The regulations and requirements for registration as a Chemistry teacher in Ireland have been updated to create a better symmetry between Subject Content Knowledge and Pedagogical Skills Training. This is important in light of the dual routes to Chemistry teaching, either concurrent or consecutive training.
Applicants must provide officially certified evidence of satisfactory achievement in primary degree studies (or equivalent) as outlined here: The study of Chemistry as a major subject in the degree extending over at least three years and of the order of 30% at a minimum of that period. Details of the degree course content to show that the knowledge and understanding required for teaching Chemistry to the highest level in post-primary education has been acquired. Applicants must submit details of course and practical work content completed during the degree programme together with teaching/tutorial times, lists of experiments and practicals, explicit details of standards achieved in degree studies in Chemistry with at least an overall Pass result in the examinations in Chemistry. Recognition to teach Chemistry also confers recognition to teach Science in the Junior Certificate programme. [2]

1.2 Induction and Registration

A process of Induction and full registration has also been established. It is likely that the teaching of Chemistry will benefit from the new regulations and those stricter requirements for concurrent or consecutive training courses with regard to Subject Content Knowledge will alleviate previous issues identified as negative impacts on the teaching and learning of Chemistry, such as Misconceptions about abstract concepts that teachers pass on to their students *in perpetuum*. The issue of misconceptions has been discussed in previous papers and this is one area where Chemistry Education research is informing the training of teachers.

1.3 Support for Newly Qualified Teachers and Non-specialist Teachers

The Professional Development Services for Teachers (PDST) [3] has developed a course for teachers of chemistry who are new to the profession or new to the revised chemistry syllabus. It focuses on good classroom teaching and learning practices as well as giving participants a hands-on experience to master the skills required in carrying a number of experiments. A detailed summary of the syllabus is provided with particular emphasis on the Leaving Certificate questions. Organic laboratory practical experiments are included with the emphasis on safety and following the correct procedures as outlined in the Mandatory Experiment CD. Teachers get an opportunity to set up and prepare organic compounds under the watchful eyes of their demonstrators. Safety tips, techniques tips and exam questions related to the experiments are also covered on the day. Teachers are provided with an extensive range of chemistry resources and useful websites. The Mandatory CD is made available on Day 1. The workshops are held over two days in three different locations, and pre-booking is essential.
The Royal Society of Chemistry has also collaborated with the PDST in running courses for teachers who are teaching Chemistry at Junior Certificate level although it may not be part of their primary qualification. These Chemistry for Non-specialist courses have been highly successful and those run in Limerick have involved two of the CIAAN network team. [4]

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2. Continuing Professional Development

The PDST collaborates with the Education Centre Network and other interested bodies to provide opportunities for Continuous Professional Development. One example is *iChemistry*, a portal where teachers can access a variety of resources to enhance and supplement their class material. [5] The resources include PowerPoint presentations, animations, graphics and photographs. All the material has been collected and uploaded by Irish chemistry teachers and is being shared free of charge to facilitate collaboration, resource sharing and networking among Irish chemistry teachers. The Chemistry is All Around Us Network (CIAAN) project workshops have highlighted the importance of the resources being produced by teachers for teachers.

The PDST also has a Senior Cycle Chemistry subject page, which includes news items, links to other projects and information about forthcoming events and projects. It has both a national and international collaborative aspect. [6] For example, The PDST is the national contact point for Scientix in Ireland. Scientix promotes and supports a Europe-wide collaboration among STEM (science, technology, engineering and maths) teachers, education researchers, policymakers and other STEM education professionals. [7]

In addition school-based support is offered on request, and updates regarding events and courses are circulated.

2.1 Sharing through association

The Irish Science Teachers Association (ISTA) supports science teachers of all science subjects through their network of branches throughout the country. They have a Chemistry sub-committee that reacts to proposed syllabus updates, curriculum changes, examination papers and generally lobbies for the betterment of Chemistry teaching. [8] Teachers are encouraged to join their local branch and attend meetings where they will hear about state-of-the-art ideas for teaching all science subjects.

3 Chemistry Education Research

3.1 Chemistry Education Research – bridging a gap

According to Bunce and Robinson, Chemistry Education Research should address how students learn, the factors affecting learning, and the methods for evaluating that learning. The results reported should be understandable to practicing chemistry teachers and directly applicable to the teaching/learning process. The research must be theory based; the questions asked should relevant to chemical educators and able to be tested through the experimental design proposed; the data collected must be verifiable; and the results must be generalizable. [9]

If we pause for a moment to consider language used between teachers and students, experts and teachers, peers – then the ‘Monotillation of Traxoline’ exercise attributed to Judy Lanier shown in Figure 1 crystallizes some of the difficulties we can incur. [10] Most students or adults who read this passage answer all of the questions correctly, but that does not indicate that they have any understanding of the meaning of their answers.

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The Monotillation of Traxoline

It is very important that you learn about traxoline. Traxoline is a new form of zionter. It is monotilled in Ceristanna. The Ceristannians gristerlate large amounts of fevon and then bracter it to quasel traxoline. Traxoline may well be one of our most lukised snezlaus in the future because of our zionter lescelidge.

1. What is traxoline?
2. Where is traxoline monotilled?
3. How is traxoline quaselled?
4. Why is traxoline important?

Figure 1: The Monotillation of Traxoline

Two of the objectives of the CIAAN project have been to: create a network of scientific experts and teachers in order to reduce the existing distance between the world of scientific research and the world of school; and to organise transnational conferences in order to present the current situation and the future perspectives on scientific education. Among the most successful experiences of the project in Ireland have been the workshops where experts and teachers shared their opinions of papers and publications from other countries and recognised that problems in Ireland are echoed across all the European partners. We were also informed about the types of Chemistry/Science education research and initiatives in other countries, and teachers were given the chance to think about their subject and their teaching from new perspectives.

3.2 Chemistry Education Research groups in Ireland

Chemistry Education Research is a relatively new discipline but a number of groups have developed around the country, largely, but not always, based in colleges which provide Initial Teacher Education. The network in Ireland includes members of the Chemistry Education Research Group (CERG) in the University of Limerick [11] and the Chemistry Education Research Team (CERT) in Dublin Institute of Technology. The former is directed by Dr Peter Childs, an associate of the CIAAN, who is internationally renowned for his work in this field. Peter Childs has promoted a number of initiatives to enhance uptake and teaching of Chemistry and has written most recently about the state of chemical education in Ireland. [12] The current research themes of the group have formed part of the publications lists for the CIAAN and include addressing the issues of misconceptions in chemistry teaching and learning, [13] language in chemistry education [14] and inquiry-based initiatives for teaching and learning including the SALiS project. [15]
CERT has very close links with the Royal Society of Chemistry and has participated in the CIAAN and been referenced for its work on Technology Enhanced Learning. [16]
Dublin City University also has an active research team and the work of Finlayson and Kelly on ‘Skills Auditing’ for new students, and McLoughlin and Finlayson on ‘Multidisciplinary Approaches’ to try to improve student perceptions and experiences in Chemistry have been discussed within the network. [17] [18]

3.3 Access to International Chemistry Education Research

The Royal Society of Chemistry publishes Chemistry Education Research and Practice (CERP) - a journal for teachers, researchers and other practitioners at all levels of chemistry education.[19] It is published free of charge, electronically, four times a year. The objectives of the journal are almost mirrors of the objectives of CIAAN: To provide researchers with the means to publish their work in full in a journal exclusively dedicated to chemistry education; To offer teachers of chemistry at all levels a place where they can share effective ideas and methods for the teaching and learning of chemistry; To **bridge the gap** between the two groups so that researchers will have their results seen by those who could benefit from using them, and practitioners will gain from encountering the ideas and results of those who have made a particular study of

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the learning process. Its current editor, Keith Taber, has written extensively on the scope and value of Chemistry Education Research. [20]

3.4 The National Centre for Excellence in Mathematics and Science Teaching and Learning

The National Centre for Excellence in Mathematics and Science Teaching and Learning (NCE-MSTL) was established in University of Limerick in 2008 and is an associate partner of CIAAN as well as providing one of the team of experts. [21] Projects in the Centre address important issues such as adapting good practices in mathematics and science teaching and learning for use in Ireland by research interventions in schools and other institutes and piloting such practices. These are then disseminated through CPD events organised by the Centre and all materials are made available on the NCE-MSTL website.

4 Information Communication Technology (ICT) and Chemistry Education

4.1 ICT and Chemistry Teaching

The CIAAN has collected a database of resources, publications and papers – all accessible through ICT. Many of these are electronic versions of paper publications, but there are also links to modelling programmes, simulations and other elements of potential for active learning. The teachers and experts have largely been positive in their comments on these resources but in terms of the Virtual Learning Environment (VLE) we acknowledge the comment by Michael Seery ‘a very valuable study of chemistry students’ perceptions of their university education conducted by the HEA Physical Sciences Centre (Higher Education Academy 2008) on their perceptions of their university education. When asked about “e-learning”, students reported that it was the least effective and least enjoyable teaching method. A similar result was derived from institutional use of virtual learning environments across several institutions in Ireland’. [22] Indeed responses to questionnaires about CIAAN resources tested by Irish teachers and students showed that while the students valued the imagery and active components of the work, they saw them as an add-on (sometimes taking up to much of their education time) rather than a replacement for the classroom experience.
Seery and Claire McDonnell (a CIAAN expert) guest edited a special edition of Chemistry Education Research and Practice on the theme of technology in chemistry education. [23] They conclude that technology does have a place in teaching but as a means to support and enhance rather than as a substitute for good teaching practice. Multimedia resources can be effective in cognitive scaffolding but an awareness of their effectiveness and how and when they should be used is paramount.

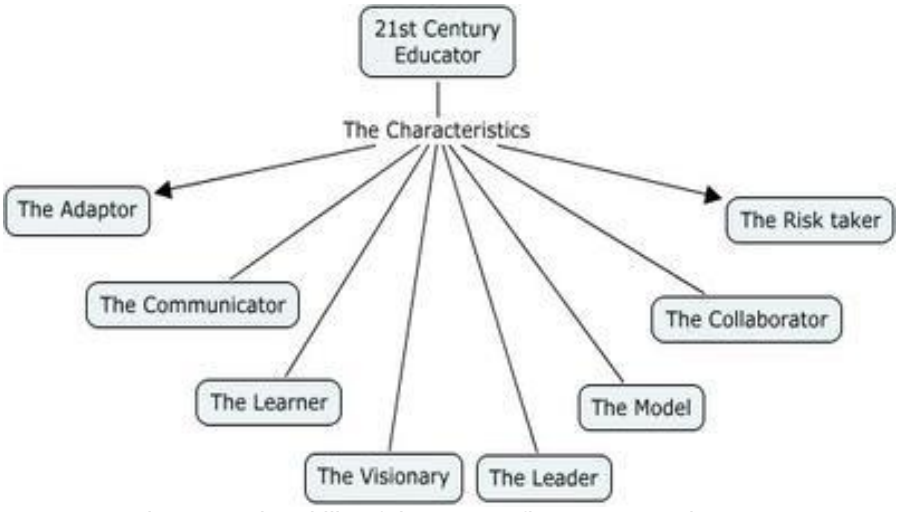

Figure 2: The skills of the twenty first century educator

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4.2 Twenty-first century teacher tools

To be an effective twenty-first century teacher, a teacher must have the same twenty-first century skills as their students are expected to have, and they must also be enablers for the students to acquire and develop these skills. It is significant that much of the CPD carried out by the PDST in Ireland in the last number of years has centred around the use of ICT in enhancing Chemistry teaching and learning. A committed educator will keep up to date with new ideas and technologies that can be implemented to help engage and educate their students. As Figure 2 shows, the traditional didactic method of communicating with students is long out of date, and teaching involves a continuum of learning, evolving and developing new skills for the teacher as well as the educator. [24]

4.3 One most excellent ICT-based resource: LearnChemistry

Throughout the discussions on good practice and successful experience, one source can be referred to over and over again as a repsoitory of ideas: the Royal Society of Chemistry's Learn Chemistry portal. [25] This fantastic website has 2859 resources for teaching chemistry, categorized for pupils from early primary to post-secondary level. It includes: Presentations, Videos, Handouts, Worksheets, Wikis, Quizzes, Experiments, Games, Tutorials, Websites, Substances, Podcasts, Simulations, Articles. This wealth of material is astonishingly well-selected and reviewers from six other countries in CIAAN were highly positive about this fantastic resource.

5. Conclusions: The Importance of Networking and Sharing

5.1 Successful Experiences

The group of experts, teachers and associates in the Irish CIAAN team are colleagues who have previously collaborated in one or more of a number of ways; chemistry education research, the Irish Science Teachers Association, SciFest, PDST, workshops, ChemEd conferences, National Centre for Excellence in Mathematics and Science Education, etc. We all have a number of things in common – we love teaching Chemistry/Science, we value and participate in CPD, we appreciate the value of networking and sharing. Our workshops have followed the practice af active participation and the comments of the teachers and experts in their testimonials evaluate their experiences of the project:

'I use the teaching resource section of the portal almost every day when preparing classes or looking for new ways to teach a particular topic. The interactive resources are particularly useful, as ICT is now an integral part of the teaching and learning experience.'

Mairead Glynn

'Each time we met I left feeling energised and enthusiased about teaching and had lots of New ideas to try in the classroom. '

Michelle Herbert

Being involved in a European project of this nature has been a very worthwhile experience. It provided both my students and me with more resources and a greater understanding of how chemistry could be taught and learned in the classroom.'

Ciara O'Shea

5.2 Good Practices

Testing of resources by teachers and students shows that preparation and advance testing by teachers is important. The students must also see where the resource 'fits' with their coursework. For example, one teacher tested an Acid-base titration simulation with a group of upper secondary level students. [26] The teacher and student evaluations showed that while the resource was helpful, it was best used as revision after the actual laboratory and theoretical work had been completed, to reinforce the concepts covered. Some students liked the fact that they were given instant feedback to calculations, but others complained about it being too time-consuming.

The American Chemical Society has identified a number of strategies for effective Chemistry teaching, starting with the recognition that what we see and perceive in the macroscopic world is a result of interactions at the microscopic level, and that we expect our students to observe macroscopically and

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explain microscopically. [27] For active student engagement in learning, advance planning is crucial, as testified by CIAAN testing of resources. Spiralling the curriculum from the broad concepts in relevant contexts to the abstract micro level may increase student engagement and participation in the Chemistry class. The 5E learning cycle in Figure 3 may be one method of focussing on and achieving Good Practice. [28]

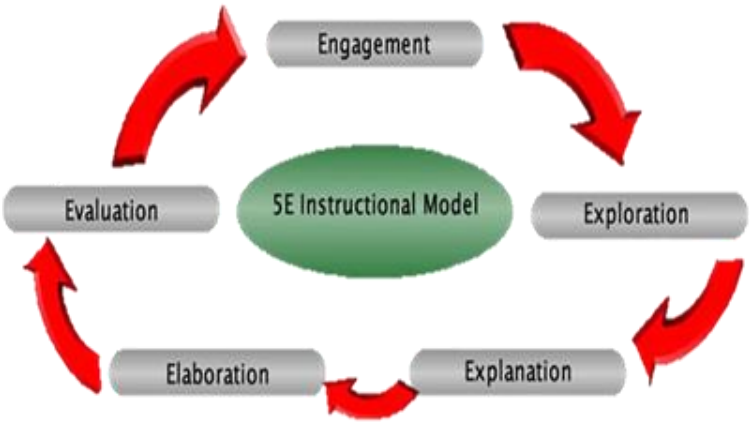

Figure 3: The 5E Learning Cycle

At each stage of the cycle there is scope for utilisation of resources and ideas shared on the CIAAN portal. However, at the heart of the instructional model is the teacher and good teaching, successful experiences and good practices are dependent on the teacher's willingness to continuously reflect and develop.
In conclusion, a lot of work has been done, more is on-going, and consolidation is desirable. The sustainability of the work is assured by the commitment of the network members and continued communication and collaboration as well as dissemination will bear fruit.

6. References

[1] Shaw, G.B. (1903) Man and Superman, Maxims for Revolutionists.
[2] Initial Teacher Education in Chemistry: www.teachingcouncil.ie and Subject specific criteria
[3] http://www.teachingcouncil.ie/_fileupload/Registration/General_and_Special_Requirements_for_Degree_Recognition_June2011%2053901607.pdf
[3] Chemistry Induction course http://www.ista.ie/news/pdst-chemistry-induction-course
[4] Chemistry for Non-Specialists http://www.rsc.org/Education/Teachers/CPD/ChemNonSpec/index.asp
[5] iChemistry: http://www.ichemistry.ie/
[6] http://www.pdst.ie/sc/chemistry
[7] Scientix: http://www.scientix.eu/web/guest/home;jsessionid=9BA717F3505B1760ED70D5223FC50AF4
[8] Irish Science Teachers Association: www.ista.ie
[9] Bunce, D.M. and Robinson, W.R. "Research in chemical education – the third brand of our profession," Journal of Chemical Education, 1997, 74(9), p1076
[10] "The Montillation of Traxoline" was written by Dr. Judith Lanier, professor and dean emeritus, Department of Education, Michigan State University
[11] Chemistry Education Research Group: http://www.cerg.ul.ie/
[12] Childs, P.E. (2014) The state of chemical education in Ireland, Irish Chemical News, 1, 16-25. Available online at http://www.chemistryireland.org/html/ichemnews.html.
[13] Sheehan and Childs (2011) Pre-Service Irish Science Teachers' Misconceptions of Chemistry, ESERA Conference Proceedings, available at: http://www.esera.org/publications/esera-conference-proceedings/science-learning-and-citizenship/strand-12/

Lifelong Learning Programme

This project has been funded with support from the European Union.
This material reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

[14] Childs and Sheehan (2009) What's difficult about chemistry? An Irish perspective, Chemistry Education Research and Practice, 10, 204
[15] Chemistry in Action! Issue 97 SALiS Special (2012) http://134.102.186.148/chemiedidaktik/salis_zusatz/material_pdf/special_issue_on_chemistry_in_action.pdf
[16] Chemistry Education Research Team: http://www.dit.ie/chemistry/research/cert/
[17] Kelly, O.C., Finlayson, O.E., (2010) Easing the transition from secondary school to higher education through recognition of the skills of our students
[18] McLoughlin, E., Finlayson, O. (2011) Engaging first year students through a multidisciplinary approach http://icep.ie/wp-content/uploads/2011/02/Engaging-first-year-science-students-through-a-multidisciplinary-approach.pdf
[19] Chemistry Education Research and Practice: http://pubs.rsc.org/en/journals/journalissues/rp#!recentarticles&all
[20] Taber, K.S. "The nature and scope of chemistry education as a field," Chemistry Education Research and Practice, 2012, 13, 159-160
[21] National Centre for Excellence in Mathematics and Science Teaching and Learning http://www.nce-mstl.ie/about-us.8.html
[22] Seery, M.K. (2013) Harnessing Technology in Chemistry Education. New Directions 9(1), 77-86. DOI: 10.11120/ndir.2013.00002
[23] Seery, M.K., McDonnell, C. (eds) The application of technology to enhance chemistry education, Chemistry Education Research and Practice, 01 July 2013, Issue 3, pp 223 to 353 http://pubs.rsc.org/en/content/articlepdf/2013/rp/c3rp90006a
[24] http://edorigami.wikispaces.com/Facilitating+21st+Century+Learning
[25] www.rsc.org/learn-chemistry Reviewed at http://chemistrynetwork.pixel-online.org/TRS_scheda.php?art_id=45&lck=&top=&pep=&sua=&tgl=&ltr=&q=
[26] Acid-base tutorial: http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/flashfiles/stoichiometry/acid-base.html
[27] Recommendations for teaching of high school chemistry http://www.acs.org/content/dam/acsorg/education/policies/recommendations-for-the-teaching-of-high-school-chemistry.pdf
[28] The 5E learning cycle http://mypage.siu.edu/~SIU851207991/5e.html

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