LIMERICK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA LUIMNIGH

518300-LLP-2011-IT-COMENIUS-CNW

Successful Experiences in Chemistry Teaching in Ireland

Lifelong Learning Programme

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SUCCESSFUL EXPERIENCES IN CHEMISTRY TEACHING IN *IRELAND*

MARIE WALSH
LIMERICK INSTITUTE OF TECHNOLOGY
LIMERICK, IRELAND
MARIE.WALSH@LIT.IE

Abstract

Across Europe, and indeed the rest of the world, the future of Chemistry as a subject for teaching, as well as learning, and for appreciation in the continuum of lifelong learning, has been a cause for concern. Public perceptions of chemistry and chemicals have suffered from negative reinforcement and stereotyping. As a result, secondary and tertiary level Chemistry has declined in popularity. Many initiatives have been designed and implemented to try to redress this issue, and some of these have proved very successful. While it is acknowledged that Chemistry will probably remain a minority subject, its importance and relevance to the everyday life of twenty first century citizens should not be devalued. To ensure a quality experience of Chemistry for students it is important to put the teacher at the heart of the process. Successful experiences may involve implementation of new technologies or new pedagogical techniques but their success depends on the initial training of the teachers as well as support for their continuous professional development. This report reviews the current situation in Ireland and describes initiatives to encourage an appreciation of Chemistry among our student and general populations, and to promote and support teaching of Chemistry.

1. Introduction

Chemistry IS all around us: Food, clothes, fuels, medicines, cosmetics, detergents, materials, biochemical in living organisms – the list of items and ways in which our lives are impacted by Chemistry is endless. Yet, Chemistry struggles to achieve a positive image in the eyes of the general public because of negative uses of the words 'Chemistry' and 'Chemicals' in regard to warfare and environmental damage. This is at least part of the reason why 'Chemistry' as a school subject has declined in popularity. It is also seen as a 'mathematical' and abstract subject and therefore appeals to the academically elite. These are unfortunate misconceptions since Chemistry also offers the opportunity to develop transferable skills like observation and analysis.

The *Chemistry Is All around Us Network* [1] project has provided an opportunity for reflection on ways to motivate students, train teachers and inspire successful experiences and good practices. Sharing the experiences with other countries has also encouraged a crystallization of what is happening in Ireland in regard to successful experiences and good practices. However, initial teacher training should form a solid foundation in terms of Subject Content Knowledge and Pedagogical Skills Training, thereby giving the teacher the confidence to teach their subject well. Access to sources of support and continuous professional development opportunities throughout the teaching career is vital in this constantly evolving technological age.

1.1 Initial Teacher Education and Training: Primary Teacher Training in Science

There is considerable anecdotal evidence that teachers who have not received any science pedagogical training pre-service are less confident and competent with implementation of the science curriculum. A major initiative to redress this issue at primary school level has been the highly successful Discover Primary Science and Maths programme.[2] The latter is a flagship project of the Discover Science and Engineering (DSE) awareness programme.[3] It facilitates teacher training in general primary science, and provides teachers with useful online resources – that can also be used by parents and students – and classroom activity packs.

Just over 3,100 primary schools and their teachers are currently participating in activities which include hands-on induction days which are hosted throughout the country in colleges of education, institutes of technology, universities and education centres. Limerick Institute of Technology [4] participated in this programme, in the

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first instance undergoing training as trainers and then facilitating training sessions with teachers in the region. The idea was that each primary school would nominate one teacher to participate in the training sessions and then s/he would go back to train other teachers in her/his school.

The National Centre for Excellence in Maths and Science Teaching and Learning (NCE-MSTL) [5] at the University of Limerick has provided in-service training opportunities for primary teachers. Typically these have been half-day workshops presenting ideas and sharing methodologies for introducing science to primary level students. This author has participated in presentation of these training sessions, which were well-attended largely by experienced teachers. One of the *Chemistry is all Around Us Network* Associate partners, Dr Maeve Liston, is the Science Education Tutor in Mary Immaculate College Limerick and has done considerable work in revamping the science curriculum and also reporting research findings on different innovative approaches to primary science, e.g. in the use of Concept Mapping [6] and Puppets [7]
More importantly for future generations of primary school teachers and their prospective students is the fact that science is being built in to undergraduate teacher training programmes.

1.2 Initial Teacher Education and Training: Secondary Teaching in Science and Chemistry

Post primary teachers are normally required to teach at least one subject which they have studied to degree level. They may also be required to teach other subjects which they have not studied to degree level but in which they have developed expertise. Post-primary teachers do not need to have a qualification in the Irish language unless they are employed by a Gaeltacht school or a school where Irish is the medium of instruction.
Qualification is usually achieved by gaining a primary degree from a recognized third level institution and the degree must include at least one subject from the curriculum for post-primary schools for the Leaving Certificate Programme. The primary degree is followed by a postgraduate qualification in education such as the Postgraduate Diploma in Education (P.D.E.).
Another path to qualification is gaining a degree which is awarded by a recognized third-level institution on the basis of a concurrent course of academic study and teacher training. All teachers must be registered by the Teaching Council. A member of staff from the Teaching Council will visit all colleges or universities to provide information about the role of the Council and on teacher registration to final year students. At this information session, they will be required to fill in a form which authorizes the college or university to transfer contact and exam result details to the Teaching Council. Currently, there is no charge applied when a new graduate is added to the Register of Teachers. New graduates will be granted conditional registration until they have successfully completed a process of induction (for post-primary teachers) or probation (for primary teachers).

1.3 Requirements for registration as a Chemistry teacher

Applicants must provide officially certified evidence of satisfactory achievement in primary degree studies (or equivalent) as outlined below.
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. Details of degree course content where the studies involved modular or applied subject content or where studies were in a related subject area will require specific assessment to determine equivalence. Details of course and practical work content completed during the degree programme together with teaching/tutorial times, list 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. [8]
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.

1.4 Support for the Newly Qualified Teacher: PDST Chemistry Induction Course

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The PDST has developed this 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. [9]
This course has a number of Learning Outcomes: On successful completion of this course, participants should be able to: Apply the structure and content of the Chemistry syllabus, Teacher Guidelines and a support starter pack; Identify and investigate best practice in laboratory management; Choose effective teaching methods, such as Assessment for Learning, for communicating Chemistry; Demonstrate practical hands-on experience with experiments listed in the syllabus; Discuss and reflect on their own teaching and share experiences and useful resources with colleagues; Undertake some action research in teachers' own work situations, reflect on practice and document the outcomes.

1.5 Supports for Non-Specialist Chemistry Teachers

There has been considerable research into the importance of Subject Content Knowledge (SKN) as opposed to Pedagogical Content Knowledge (PCK). The reality is that many teachers of Junior Certificate Science, who have to teach Chemistry as part of that programme, are not sufficiently qualified and/or competent to teach Chemistry confidently. The Royal Society of Chemistry has developed a Chemistry for Non-Specialists' course which is designed to support these teachers in their Chemistry teaching. [10]
This training programme is aimed at those who teach chemistry in a secondary school but hold a specialism in a different subject. The programme is designed to provide such teachers with the confidence, flair and enthusiasm to teach chemistry at secondary school even though it is not their primary subject. It comprises a two-day course and two one-day follow-up events at approximately one term intervals, delivered by experienced chemistry teachers, trained by the RSC. This experience of Chemistry provides excellent opportunities for engaging with practical work and provides the teachers with opportunities to develop these important skills to illustrate key ideas and phenomena. It identifies the topics that challenge students' conceptual understanding of chemistry and provide teachers with strategies to tackle them. Links to relevant contexts are made throughout and chemistry career opportunities for prospective students are presented.

1.6 Professional Development Service for Teachers

The Professional Development Service for Teachers (PDST) also offers opportunities for in-service training in Science. The PDST was established in September 2010 by Teacher Education Section (TES) of the Department of Education and Skills (DES) following a re-conceptualization of support and continuing professional development (CPD) for teachers in primary and post- primary schools. Currently PDST encompasses the supports previously supplied by other support services and programmes, including Primary Professional Development Service (PPDS) and Second-Level Support Service (SLSS). The aim of PDST is to provide high quality professional development and support that empowers teachers and schools to provide the best possible education for all pupils /students. Its mission is to support teachers as reflective practitioners by promoting teacher learning, collaboration and evidence-based practice. Supports and CPD available to principals and teachers include Subject-specific and curriculum support, Teacher professional networks (TPNs), online learning and support and In-school support in a range of areas to support learning and teaching. Current training is focusing on Literacy and Numeracy, but there is on-going work in integration of ICT for subject support. [9]

1.7 Chemistry Demonstrations Workshop

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This course has run for one week in June for each of the last eight years. It aims to help teachers to become more confident in doing chemical demonstrations in school at Junior Certificate and Leaving Certificate level, and covers safety aspects and the use of ICT in demonstrations.

Chemistry Demonstrations Workshop: featuring associate partners of Chemistry is all Around Us Network

Teachers, working in pairs, are also required to research, devise, test and present a 10-20 minute chemical magic show at the end of the course to their peers. These shows are videoed and a copy of them provided on DVD after the course. There is also an opportunity to demonstrate and share with the other teachers.
There is also an opportunity during the course to watch experienced demonstrators live and on video, to access printed and internet resources on demonstrations, and to leave with materials and tested demonstrations for use in schools. The course is residential but highly subsidized which makes it affordable.
In Ireland teachers have a number of supports that can be accessed to help their Chemistry teaching, although the most negative aspect of delivery of what should be a practically enhanced subject like Chemistry is the lack of technical support in schools. [11]

1.8 The Irish Science Teachers Association (ISTA)

The Irish Science Teachers Association (ISTA) is the Subject Association for teachers of Science in the Republic of Ireland, with over 1,200 members. Branches hold frequent meetings of interest to Science teachers, and the Association has had representation on the various syllabus committees which drew up the revised programmes in the various Science subjects. The Association has several Sub-Committees which do valuable work in the various subject areas. The ISTA holds an AGM in the spring of each year with a very broad programme of interest to people in different areas of Science education. Trainee teachers are included in membership and all activities of the ISTA. [12]

1.9 The Royal Society of Chemistry (RSC)

The RSC is a fantastic resource for chemistry teachers around the world. There is an RSC Education Division subcommittee in Ireland. Membership of this ten-person committee includes the *Chemistry is All around Us Network Ireland* manager, one expert, one associated partner and one teacher. This committee supports and funds initiatives to improve the teaching and learning of chemistry in Ireland.
In addition Limerick Institute of Technology has become a member of the *Learn Chemistry Partnership* of the RSC. This initiative aims to support chemistry education through collaboration with RSC Education Managers and the excellent web portal Learn Chemistry. [13]

1.10 Chemistry in Action! Magazine

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This magazine is published three times annually and sent free of charge to approximately seven hundred Irish chemistry/science teachers. It aims to keep the teachers up to date with new ideas in chemistry and pedagogies, and includes resource news and event updates. The magazine is sponsored by chemical and pharmaceutical industries as part of their education and outreach activities. During the lifetime of the project it has supported the dissemination activities. [14]

1.11 Chemed Ireland annual conference

The ChemEd-Ireland annual conference is an annual one-day conference held to provide an opportunity to share ideas and resources relevant to teaching chemistry and science in Ireland. [15] It is attended by both pre-service and in-service teachers and includes a mixture of interactive talks and workshops. The theme of the 2013 conference, which was hosted by Limerick Institute of Technology, was *New Perspectives for Chemistry Teaching* and the conference proceedings will be published in *Chemistry in Action!* in 2014. The attendees had the opportunity to hear from the new Chief Examiner for Chemistry, Dr. Fiona Desmond, and to share new ideas on the use of technologies in the classroom among other topics. This event is supported by the PDST, RSC and the Society for the Chemical Industry.
Marie Walsh and one of the teachers involved in the network have been invited to give an update about the Chemistry is All Around Us Network project at ChemEd-Ireland 2014 on October 11th in Dublin Institute of Technology.

1.12 The National Centre for Excellence in Maths and Science Teaching & Learning

The National Centre for Excellence in Maths and Science Teaching & Learning (NCE-MSTL) [5] was developed to address issues in the teaching and learning in science and mathematics by conducting best practice, high level evidence-based research into teaching and learning in mathematics and science - incorporating all learning environments - formal, non-formal and informal. It is collaborating and sharing information with all universities and institutes in order to formulate strategies that enhance mathematics and science teaching and learning from primary school, through secondary school to third level and fourth level. In addition it aims to translate existing research into effective best practice in mathematics and science teaching and learning, and to achieve this through designing, informing, advising and delivering nationally recognised evidence based CPD programmes. It currently has a cohort of postgraduate researchers, many of whom are carrying out research relevant to modifying and enhancing teacher training.

1.13 Institute of Chemistry of Ireland

The Institute of Chemistry of Ireland is the professional body representing chemists in Ireland. It promotes good practice in chemistry and maintains strong links between chemistry education and industry. The Institute produces a magazine *Irish Chemical News* and holds an annual congress. The Institute is an Associate Partner of the *Chemistry is All Around Us Network* and the network will be promoted at the congress in Limerick Institute of Technology in September 2014. [16]

1.14 Pharmachemical Ireland

PharmaChemical Ireland's mission is to lead the sector towards achieving its vision by bringing together all relevant stakeholders in the State, namely industry, government, research community and the public at large to effectively communicate the unique attractiveness of this country as a leading location for the supply and development of such products. Its aim is that with the support of industry, Ireland will position itself as a recognised centre of excellence for innovation and development in pharmaceutical, biopharmaceutical and chemical supply, thereby becoming the location of choice for the launch of new products. To this end it encourages industries to support and participate in educational initiatives.It provides funding for educational initiatives in Chemistry and has become an associate partner of the network. [17]

1.15 Chemistry is all around us network

The network of teachers and experts has undergone changes in the lifetime of the project, and the associate partners have become very important as they are representatives of some of the activities outlined above. On

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a trial basis a Facebook page has been set up. Any information about new resources posted there will also be placed on the Chemistry is All Around Us Network portal.

Screencapture of the Facebook page

2. Key competencies and their development in chemistry education

During the lifetime of the *Chemistry Is All Around Us Network* project the education system in Ireland has been in a state of flux. There has been a revamp of the requirements for teacher training and qualification. There is on-going work in developing new syllabi and modes of assessment for secondary school Junior Certificate Science and Leaving Certificate Chemistry. New Chief Examiners have been appointed for Junior Certificate Science and Leaving Certificate Chemistry. There has been restructuring of the trainer teams in the Professional Development Support for Teachers (PDST) Service. In early July 2014 the Minister for Education and Skills, whose office had been driving many of the reforms, announced his resignation. How this will impact on the said reforms remains to be seen. The new Minister for Education, Jan O'Sullivan, has said that she intends to progress the reform process and this will undoubtedly have an effect on Science education.

The OECD PISA (Program for International Student Assessment) is an on-going programme assessing 15 year old students in 30 OECD countries as well as some non-OECD countries.[18] The assessments in reading, mathematical and scientific literacy are repeated on a three yearly cycle. Scientific literacy questions are contextualized and designed to test the scientific knowledge and skills which are essential for full participation in society. [19] The most recent scientific literacy data from PISA places Ireland's 15 year-olds ninth in the list of thirty countries. This was an improvement of five places from the previous study. Despite the strong improvement, business body IBEC has warned Ireland can never allow itself to grow complacent again when it comes to quality education and performance.

The first three years of secondary education in Ireland culminate in the Junior Certificate examination. Ireland is unusual in that Science (an integrated subject combining elements of Chemistry, Biology and Physics) is not a mandatory subject for Junior Certificate students in all schools. As Table 1 shows, just over 10% of students do not study Science at Junior Certificate level: it is highly unlikely that these students will go on to study science subjects at senior level.

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Year	2011	2012	2013
Total Junior Cert cohort	59,823	58,798	56,930
Junior Cert Science Higher level (%)	42,423 (78.69)	39,990 (76.02)	38,072 (75.31)
Junior Cert Science Ordinary level (%)	11,489 (21.31)	12,615 (23.98)	12,485 (24.69)
Junior Cert Science Total	53,912	52,605	50,557
% boys:girls	51.9:47.9	52.1:47.9	52.6:47.4
% cohort taking Junior Cert Science	90.12	89.47	88.81

Table 1: Uptake of Junior Certificate Science (source State Examinations Commission)

However, chemistry education at second and third level is in a relatively healthy state. The number of students taking Leaving Certificate Chemistry has recovered from a low of 11% to over 15% as shown in Table 2. In 2013 a total of 8,155 students, representing 15.45% of the Leaving Certificate cohort, sat the Leaving Certificate Chemistry examination; 82.8% of these were Higher level and 17.2% Ordinary level candidates. The hidden reality is that many of the Higher level candidates take the exam because it is a prerequisite for a number of third level course like Medicine, Pharmacy and Dentistry rather than studying Chemistry for Chemistry's sake alone.

Year	Leaving Certificate Chemistry candidature	Total Leaving Certificate candidature	% Chemistry candidature
2009	7403	54196	13.7
2010	7548	54481	13.9
2011	7677	54341	14.1
2012	8086	52589	15.4
2013	8155	52767	15.5

Table 2: Chemistry as a proportion of Leaving Certificate candidature (source: Chief Examiner's Report 2013)

The Leaving Certificate Chemistry syllabus is at an advance stage of revision. The draft syllabus has been widely circulated and commented on and is an advanced stage of preparation. The most significant change will be the examination of a practical component in addition to the terminal written examination.
Chemistry education research continues to grow and also to be given more recognition. A number of institutions and individuals are participating in European and other transnational projects and taking advantage of sharing successful experiences with colleagues from around the continent and indeed the rest of the World. The *Eurovariety in Chemistry Education* conference was held in Limerick in July 2013 and was typical of the international sharing of expertise and best practice.
The quality of Science and Chemistry education in schools and colleges is key to sustaining Ireland's status in international high tech industries. *De facto* the quality of initial teacher training and on-going continuous professional development for teachers is critical to maintaining quality in education. Successful experiences and good practices arise from reflection and understanding of the needs of the student population at all age levels, as well as the needs of society and industry.
While Ireland still has the highest birth rate in the EU, it shares a number of issues with all EU partners, not least the immigrant population for whom English is not their native or first language. In common with many technical subjects, Chemistry has its own language and therefore we must look at that from two viewpoints: Understanding and managing difficulties with language needs to address the 'new' language of Chemistry but

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also the complication of learning this new language in English when that may not be the first language of the learner.
The nature of our world and our increased reliance on Information Communications Technology (ICT) has changed the pedagogical approaches of most educators. We assume that our students are technologically

literate although this may be as variant as their Science or Chemistry literacy. Technology used well can enhance the teaching and learning process but it can never replace a quality teacher. The teacher is at the heart of the learning process for the majority of students. However, as Figure 1 shows teachers also have to develop new pedagogical approaches and strategies to engage and motivate the twenty-first century learners.

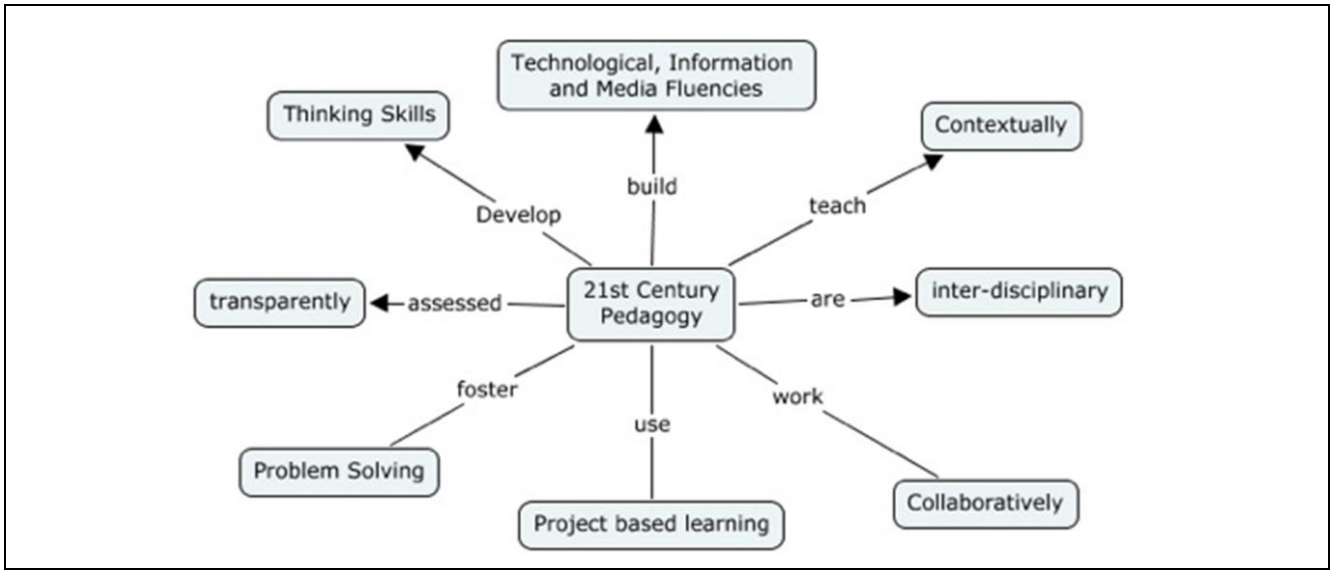

Figure 1: Twenty-first Century Pedagogy – teaching at the heart of learning

In 2012, students in Irish schools ranked 8th out of the 19 countries that participated in the OECD's Digital Literacy test. Just four countries, Korea, New Zealand, Australia and Japan, had significantly higher scores than Ireland. The Government has acknowledged that embedding digital literacy in the school curriculum is an imperative. There is on-going development of ICT infrastructure in Irish schools.
In-service professional development for teachers is underpinning the roll out of technology. This is evident in continuous professional development sessions for science/chemistry teachers. The Professional Development Service for Teachers hosted Chemistry network meetings in Autumn/Winter 2013. These evening meetings took place in Education Centres throughout the country. Each of these meetings consisted of a workshop on the use of resources produced by a team of experienced Chemistry Teachers, including the following topics: Assessment for Learning: Chemistry apps for personal computer and phones to aid assessment for learning strategies; Chemical Formula Resources; 'Stimulus to engage activities' to kick start lessons. Teachers were invited to bring smartphones and/or tablets. [20]
In the context of Successful Experiences, technology will only make a difference if used appropriately. A study carried out by the UK Higher Education Academy Physical Sciences Centre in 2008 of students' perceptions of their university learning experience in Chemistry recorded that electronic instruction was judged by the students to be their **least effective** and **least enjoyable** teaching method. [21] The onus is on teachers to integrate technology appropriately to supplement traditional teaching methods.

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3. Examples of successful experiences

3.1 a. Challenges of language in Chemistry

In the context of the *Chemistry is All Around Us Network* project, one of the publications chosen to illustrate Successful Experiences addresses the issues of linguistics in Chemistry. Rees, Bruce and Nolan discuss the outcomes of research at Durham University into effective teaching strategies to enhance understanding of subject specific language by international and non-traditional students. [22] Teaching strategies with an emphasis on improving scientific literacy were trialled over the course of the academic year 2010/11 in Foundation Level Chemistry. The authors describe various strategies that they employed, including the use of play dough for atomic and molecular modelling, word games, using analogies, and the development of glossaries as well as DARTS (Directed Activities Related to Text).

The outcomes from these initiatives led to the development of an E-glossary to support the development of subject language understanding. The E-glossary was trialled over the next academic year. The result is a glossary of student generated content (with over 100 contributions) explaining scientific terms and concepts in a variety of ways at an appropriate level for foundation students. Each of the terms is described in the relevant technical depth and many of them include an animation or other video. The students as well as the teachers can edit the material. The web portal for the students also includes a section on Scientific Language Skills for Learning. This looks at scientific language in general as well as ways to develop reading and vocabulary and to write scientific reports.

3.1 b. Benefits of skills auditing

It is vital that teachers at any level have some understanding of the skills levels of students. This is perhaps most critical at third level where we cannot take for granted the previous academic experiences of our new undergraduates. There are only a small number of third level courses that specify a student must have studied Chemistry at second level. This means that a new undergraduate cohort on a course where Chemistry is a core subject will have a diverse range of prior experiences of Chemistry, from no experience beyond Junior Certificate to excellent experience at higher secondary level or beyond. Skills auditing of such a cohort can provide a focus for what and how we teach Chemistry. Some lecturing teams have seen the benefits of placing Chemistry in a multidisciplinary context or using Active learning and Inquiry-based strategies for teaching and learning.

This study by Odilla Finlayson and Orla Kelly in Dublin City University developed from recognition that the transition from school to university can be daunting for many students. [23] While students must have demonstrated a particular level of academic ability to gain entry to college science courses, their skills are rarely audited. The authors suggest that this may result in teachers placing both subject knowledge and skills demands on students. They may be assumed to have certain skills because of their degree subject choice, but in fact might not have particular skills to enable them to make progress with their subject knowledge and understanding, resulting in them making little or no progress, coupled with a feeling of frustration. The recent shift towards context and problem-based learning approaches to teaching the physical sciences may cause particular difficulties for students who have no previous experience of this type of learning as they transit from the rote-learning domination of secondary school.

The authors developed a problem-based approach which was introduced to the Year 1 chemistry laboratory module taken by students on the BSc in Science Education at Dublin City University, Ireland. To better inform the module development and enhance the skill-set of the students it was decided to carry out a skills audit of the first year students at the start of their university course. Forty four students from the 2002–2003 and 2003–2004 cohorts completed the skills survey. This identified what skills students felt they were confident in using, and which skills the students had had little opportunity to develop.

The survey was adapted from the RSC's Undergraduate Skills Record (USR).[24] Various skills were identified in the USR which were seen to be important for first year undergraduate students, such as interpretation of laboratory measurements and observations and using feedback to improve on future work.

Examples of interventions developed for the Problem-based Learning module include: incorporating oral (PowerPoint) presentations into the laboratories; getting students involved with the development of experiments by researching appropriate techniques and procedures using the internet and other resources;

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the importance of errors and evaluating experimental data was a key focus of laboratory reports and their presentations. This was done in a gradual way, increasing the skill demand across the year-long module. The qualitative result of the trial was that the students seemed to develop skills in the manner anticipated.
The authors conclude that more innovative science curricula are needed at school level science to ensure that future science undergraduates will enter courses with more developed skills. A move away from the didactic to a student-centred approach at secondary level Chemistry might encourage better skill development and more confidence to study Chemistry at undergraduate level.
The Undergraduate Skills Record (USR) is now available on-line, in an electronic format that allows students to create an account and record and save their skills continuously, set goals and future targets and generate a skills report at any point.

3.1 c Chemistry through a multidisciplinary approach

In *Making connections and underpinning relevance of Chemistry through a multidisciplinary approach* Eilish McLoughlin and Odilla Finlayson described an initiative implemented over a four year period with some seven hundred students in Dublin City University. [25] This intervention recognised issues for new undergraduates: students in first year university science programmes generally must take modules or courses in all science disciplines to a basic level. While curriculum and programme developers see the relevance and interrelations of each of the disciplines to each other and the necessity for a student to have a good foundational knowledge in each subject, the students may often not see the necessity or relevance of the other subjects. Given the low numbers of students taking Chemistry at Leaving Certificate but having to study it at basic undergraduate level there are a number of factors that inhibit performance and connection in the subject.
The aim of the lecturers was to develop a module that would highlight the multidisciplinary and interdisciplinary nature of science, that would interconnect the three science disciplines, and that would allow students to develop additional skills. The module content should encourage students to make decisions on the basis of evidence or limited data, to find relevant information, and to form opinions (based on scientific arguments) on a current scientific issue of direct interest to the public. The module was not designed to teach the basic Chemistry and other sciences but to revisit and reinforce content already covered in lectures and laboratories.
The authors surveyed the students and also conducted focus groups over the period of the intervention. They concluded that the students gained problem-solving skills and interacted well within their groups to solve the problems. They note that only forty seven per cent of students agreed that they had sufficient Chemistry knowledge to solve the problems, in contrast to seventy four per cent who agreed that they had sufficient Biology background. This can be correlated to a certain extent with the uptake of the subjects at secondary school level. However, the multidisciplinary active learning approach was met favourably by fifty four per cent of students and the module continues. Problems with significant Chemistry content included: Nuclear Energy, Water Contamination, Genetic Screening, Home Brewing, and Industrial Oil Spill.

3.1 d Active learning Initiatives

The magazine *Chemistry in Action!* devoted Issue 97 to describing an EU-Tempus funded project – SALiS, Student Active Learning in Science.[26] The central aims of SALiS were to make science education in the participating countries more motivating, more effective in the learning of subject matter and to raise its potential for the promotion of a broad range of cognitive and non-cognitive skills.
The project aimed to promote science teaching and learning through hands-on student-centred activities, based on the foundations of modern science curricula and pedagogies, in order to raise motivation, to support development of higher order cognitive skills, to produce better learning of science concepts, and to promote a broad range of general educational skills.
Sabine Streller and Claus Bolte described one part of the project, which developed a sequence of lessons situated within the context of weather, climate and climate change intending to facilitate access to the topic based on the everyday experiences of the students. [27] The sequence of ten lessons was devised for interdisciplinary introductory chemistry courses as well as for courses in integrated science.
The authors described one of the major aims of the ten-lesson sequence and a parallel case study as being to make it clear to students that scientific work not only includes conducting experiments, but also finding, working on and evaluating texts and other sources of information. The students should also learn that science

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answers certain questions but cannot answer every question. A second aim of the project was to motivate students to study science and the nature of science by making it relevant to everyday life. Having implemented the lesson sequence they carried out Motivational Learning Environment analyses that show how successful the inquiry-based science teaching approach was, both for the teachers and the students.
In a second article Streller described the contents of one workshop that teachers attended to learn how Inquiry-based Science Education (IBSE) works for themselves. [28] Experiential learning for the teachers of a new mode of instruction is essential for their pedagogical skills development.
The phases of the workshop based on 'Investigating a household product' were described:
Phase 1: Welcome and introduction regarding the meaning of IBSE, goals of the workshop.
Phase 2: Teachers (in small groups) got 'interesting' products from supermarkets (for example effervescent tablets, lactose free milk, nappies) to stimulate questions and to start the inquiry process. During this phase the teachers: talked about the product, formulated questions regarding the product, selected one of the questions, formulated assumptions to the question, planned an experiment to test the assumption.
Phase 3: Involved experimentation about the question, sometimes with the help of a structured worksheet.
Phase 4: In small groups teachers were asked to find explanations for the experiments, to reflect on their assumptions, to find answers for the questions and to formulate additional questions.
Phase 5: In the workshop the teachers had their own experience about how inquiry-based learning could work, without the need for any advanced laboratory equipment but with simple everyday products and materials. The steps of inquiry-based learning were summarized and the participants got the opportunity to discuss possibilities of transfer the IBSE approach into their own universities and classrooms.
This issue of Chemistry in Action! gave plenty of food for thought. While it was centred on the outputs of the SALiS Project, it also included items on low-cost techniques and the value of demonstrations to illustrate Chemistry concepts.

3.1 e Technology enhanced chemistry education

Michael Seery and Claire McDonnell from Dublin Institute of Technology were guest editors of a special issue of the Royal Society of Chemistry's Chemistry Education Research and Practice (CERP) in Summer 2013, with the theme *The application of technology to enhance chemistry education*. [29] The editors set the scene for the articles in the special edition in a thoughtful editorial that summarises their standpoint. They acknowledged that while technology in Chemistry education has not always been well-received, a study by Reeves and Reeves suggested that this unpopularity may be because of some implementations that have involved poor design or inappropriate alignment between the technology and the learning objectives. [30]
They selected a number of articles which demonstrate that technology does have a place in Chemistry teaching if it is appropriate and enriching to what is being taught. It will be of benefit if effectively incorporated and if it is a source of explanation, clarification and a means to practice skills and knowledge. Not least it can be a means of delivering timely and effective feedback.
The usefulness of multimedia resources such as simulations in cognitive scaffolding was discussed, with the recurring theme of careful design and utilization at appropriate points to guarantee maximum pedagogical effectiveness. There are ten papers which include reports on peer-assisted learning, the use of wikis and other collaborative instruments, assessment and feedback, and the use of simulations – among other topics. Like the issue of Chemistry in Action! referenced above, this journal issue gave plenty of material that may be a stepping stone to successful experiences in the Chemistry classroom. Overarching the content is the acknowledgement that ICTs should not be intended as a replacement for good teaching practice but to enhance and support it.
Michael Seery has also written on 'Harnessing Technology in Chemistry Education' in the UK Higher Education Academy New Directions. [31] This article extends some of the ideas from the CERP articles referred to earlier. Seery asserts that the use of technology in teaching might be considered in the context of cognitive load theory as a basis for integrating technology into Chemistry education. Examples of interventions outlined include: pre-lecture or laboratory activities, the use of personal response systems (clickers) in lectures, worked examples in a virtual learning environment, simulations, wikis as collaborative work spaces for peer discussion and peer-assisted learning, screen-casting and pod-casting, and student-generated assessment (some using Peerwise).The reality is that while there are many ways the Chemistry teacher or

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lecturer could integrate technologies into lessons, knowledge of content, pedagogy and technology must interweave to make the resource valuable to both the educator and the students.
The phenomenon 'flipped lecture' is also discussed briefly, and again this has to be micro-managed to ensure the students attain the learning outcomes and appreciation of Chemistry intended.

3.2 Experience assessment

The assessment of these experiences is on-going for the most part. Some of them use new approaches and techniques that have not been implemented long enough to be properly measured. In the case of the language skills initiatives, the positive reception of the ideas by students is a good indicator of success. Few studies have focused specifically on the role that language plays in learning chemistry. Daniel T. Pyburn *et al* have reported an investigation into the ability of language comprehension measures to predict performance in university introductory chemistry courses. This work is informed by theories of language comprehension, which posit that high-skilled comprehenders hold a cognitive advantage over the low-skilled because of a heightened ability to inhibit contextually irrelevant details and utilize prior knowledge to effectively bridge conceptual gaps when comprehending new information. Over a two-year period, data on comprehension ability, math ability, prior chemistry knowledge, and course performance were obtained in multiple general chemistry courses. Regression analyses and hierarchical linear models (HLMs) were utilized to establish relationships between predictor variables and course performance and to determine if comprehension ability could potentially compensate for low prior knowledge, a phenomenon predicted by theories of comprehension ability. Results indicate that comprehension ability correlates with general chemistry performance; it also contributes comparable information about course performance when compared to math ability and prior knowledge. In addition, they found that comprehension skill partially compensates for deficits in prior knowledge. Therefore, efforts to prepare students for success in general chemistry should include both content and the development of language comprehension skill. [32]For the multidisciplinary approaches and the skills auditing, the measure is generally the pass rate for students taking the modules. The authors of these studies have reported positive results. The reality is that we are now using non-traditional methods with non-traditional learners and education is a continuum for both students and teachers. Teachers are at the heart of learning and their embrace of new technologies may enhance the student experience but it is still the skills of the teacher at imparting core concepts that are most important in terms of the new 'blended learning' approach.

Figure 2: Word cloud on new teaching and learning strategies
(Source: http://elearningindustry.com/enhanced-learning-and-teaching-through-utilisation-of-web-based-technologies)

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4 The Impact of the Project on Successful Experiences

4.1 Sharing experiences in an international context

The international conference "Initiatives in Chemistry Teacher Training" took place in Limerick on 29th November 2013 in Limerick Institute of Technology City Campus at George's Quay. The aim of the conference was to share European experiences and initiatives for pre-service and in-service training of chemistry teachers and then to focus on initiatives to enhance chemistry teacher training from an Irish perspective. The Conference was funded by the Chemistry is All Around Network project resources. It was part of the prescribed activities of the Chemistry is All Around Us Network and follows on from the initial conference on Training Issues of Chemistry Teachers in Gabrovo, Bulgaria in June 2013.

The morning session centred around the European experiences collated through the Chemistry is All Around us Network Project, and the afternoon devoted to various aspects of chemistry teacher training in Ireland, and beyond, since some of the initiatives were instigated as part of European collaborations.

In addition to the conference talks, poster presentations were displayed, giving the participants had the opportunity to examine the posters presented and to discuss their contents with authors during the breaks midway through the morning and afternoon sessions. The full conference programme is available on the conference web site (http://www.lit.ie/ICTT/default.aspx).

Some forty participants registered from a number of European countries, with the largest representation from Ireland. These included representatives from universities, schools, educational companies and public authorities. They were welcomed to the George's Quay campus by Michael O'Connell, Limerick Institute of Technology's Vice-President for Strategy, Internationalisation and Marketing. His welcome was echoed by Michelle McKeon-Bennett, Head of Department of Applied Science in Limerick Institute of Technology.

The Chairperson for the day was David Sutton, a lecturer in the Department of Applied Science in Limerick Institute of Technology who is also a member of the Irish team of experts for the Chemistry is all Around Us Network Project.

The papers presented addressed Initial Teacher Education and In-service Education, with some of them focussing on the use of information communications technologies to enhance the teaching experience, as well as continuous professional development in the use of inquiry-based strategies. All of the European project partners spoke aboput issues and initiatives in their own countries, and the morning session concluded with a review of *Initiatives in Chemistry Teacher Training in Ireland* by Marie Walsh. This outlined the current status of reform in all education components in Ireland, which, in the case of teacher training, have been informed by the Sahlberg Report (July 2012). This concluded 'in order to advance further in its national teacher education system, Ireland needs to invest more in the continuous improvement of the quality of teaching, the role of research in teacher education, and international cooperation in all of its teacher education institutions'. The current system of pre-service training was described, with some comparison of concurrent versus consecutive training and the implications of each for subject content knowledge and pedagogical skills training. Continuous professional development to maintain the state of the art in a scientific discipline like Chemistry was recognised as being vital. To this end the talk merged with one by Peter Jackson, who described the role of the *Professional Development Service for Teachers* (PDST). He is a practising Chemistry teacher who is also a member of the PDST team for Chemistry. He explained the work of the team and their countrywide interaction at Teachers Centres. They ensure material presented at training sessions is useful, are forward-looking, cross curricular links are stressed, making resources available to all teachers and they address literacy and numeracy issues.

The conference lunch was held in the Hunt Museum, which was a short walk away from the venue for the talks. This gave participants a chance to meet partners from other countries and to discuss the issues in a less formal setting.

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Chemistry is All Around Us Network Conference attendees Limerick November2013

When the participants reconvened at George's Quay they heard an overview of the *Chemistry Is All Around Network Project: The Transnational Report* by M.M.Carnasciali and L.Ricco and presented by Marilena Carnasciali, the project leader from University of Genoa. Her report showed how the project network is expanding internationally. She has concluded that the project is making a valuable contribution to the training of teachers because it allows the experts to deal with the international reality and increase their knowledge in the field of training and to discuss with teachers of all levels, establishing a solid contact with schools, their problems and needs. It also has allowed the teachers involved to have people to contact for improving their teaching methodology and for all users of the portal to update on teaching chemistry in Europe and find ideas for new teaching methodologies.

The afternoon sessions then shifted focus to Irish initiatives. Talks were given by representatives of Chemistry and Science Education Research Groups in a number of Irish third level institutions with involvement in either or both pre-service and in-service training of teachers. Many of the presenters are members or associates of the Chemistry is All Around Us Network in Ireland. The first of these talks was from Peter Childs, one of the pre-eminent chemistry education researchers in Ireland. His talk *From SER to STL: translating science education research into science teaching and learning*, encouraged the implementation of research findings into teaching and learning.

The theme of 'Misconceptions' was a major component of *Pre-service Primary Teachers Ideas in Chemistry* by Maeve Liston. She shared her on-going research findings regarding the scientific knowledge of pre-service primary school teachers and also described proposed future work to redress the misconceptions issue: to design and implement the Conceptual Understanding Chemistry Course where the pre-service teachers will be confronted with 'chemical events' that evoke conflicts between everyday conceptions and chemical theory.

The theme continued with a description of on-going research with pre-service secondary school teachers at the University of Limerick in *Investigating and Addressing Chemistry Misconceptions in the Subject Matter Knowledge and Pedagogical Content Knowledge of Pre-service Science Teachers* which was outlined by Muireann Sheehan and co-authored by Peter Childs. Their research has shown that the level of misconceptions is high, and worryingly, that it does not decrease over the lifetime of the undergraduate training programme. Phase 2 of the research includes design of a blended-learning intervention, including a website subatomic. The intention is that this website is a place where the Pre-service science teachers can: revise their own understanding of lower second-level (Junior Certificate) chemistry topics, learn about common pupil misconceptions which they may come across in the classroom, get diagnostic questions, resources, ideas for teaching activities and information about the Junior Certificate science syllabus, learn about research ideas and strategies relevant to developing conceptual understanding and targeting misconceptions among

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their pupils, and, get advice from experienced teachers/researchers about teaching chemistry (in the form of short articles).
The next two talks shifted emphasis to the use of ICTs in chemistry teaching. Claire McDonnell from Dublin Institute of Technology addressed the topic *Applying Technology to Enhance Chemistry Education.* Claire described her experience as a guest editor for the Royal Society of Chemistry special themed issue of the journal Chemistry Education Research and Practice, before going on to talk about her own experiences of using Wikis and Peerwise. One telling quote has resonance for all: "Technology will not replace teachers, but teachers who use technology will replace the teachers who do not," Clifford, R. (Defense Language Institute) quoted in Moeller, A. J. CALICO Journal, 1997, 14 (2-4), 5-13.
Mark Glynn from Dublin City University spoke on *Using Moodle for sustainable professional development for teachers.* This talk gave an overview of the potential for Moodle, both for in-house back-up for lessons and also for distance training initiatives.
After a short break to allow discussion and viewing of posters, the final talks of the day commenced. The first of these *The use of Visual Aids for concrete learners: Facilitating understanding in Organic Chemistry* was presented by Anne O'Dwyer (in conjunction with her supervisor Peter Childs), who demonstrated her research findings supporting the use of models to facilitate understanding of structures and reactions of organic molecules. She spoke about the multi-dimensional nature of Chemistry, cognitive development and its impact on the learning and understanding of abstract ideas – and particularly the cognitive demand of Organic Chemistry. The talk concluded with illustrations of the potential for using concrete models to teach abstract concepts.
Sarah Brady, from the CASTEL Centre for Advancement of Science Teaching and Learning in Dublin spoke about *Developing and Implementing Teacher Education Programmes & Resources for teaching Chemistry*. She shared experiences of developing and implementing teacher education programmes and resources for teaching chemistry. This work has been made possible through CASTEL's involvement in two particular projects. The first is the ESTABLISH project, which is an FP7 Science in Society coordination and support project which they coordinate and the second is the Amgen Science Teacher Training Initiative, which has been run as a pilot project for the last two years. Two positive results from these initiatives have been: observed changes in the profile of teachers' understanding of Inquiry based science education and very significantly buy-in from Ministries of Education to roll out national programmes of continued teacher professional development.
The final talk of the afternoon was on *Technology Enhanced Learning in the Chemistry Classroom* by Michael Seery who was guest co-editor of the special themed issue of Chemistry Education Research and Practice alluded to earlier. He described on-going research and practice in the implementation of ideas to reduce cognitive overload for students, ideas like the use of worked examples, wikis, jump-starting lectures, podcasting and screen-casting. This gave a myriad of ideas for in-service actions that might motivate students in their studies of chemistry, and also ensure that teachers are responding to the appropriate use of technologies.

4.2 Sharing Successful Experiences in a local context

The workshop on Successful Experiences took place in March 2014 in Limerick Institute of Technology. The Participants were teachers, experts and associates of the project. The agenda for the day was distributed to the participants. Two associate partners were introduced to the group. The meeting was started by Marie Walsh who gave an overview of the project to date. This included a report on the conference and meetings in Limerick and the requirements for this phase of the project.
It was noted that website needs to be kept more up to date. Information relating to the meeting in Limerick was (and is in JULY 2014) still on the homepage. Information should now be available for the meeting in Portugal.
There followed a roundtable description of resources reviewed by each participant. Where possible the items reviewed were displayed on the screen to illustrate their usefulness.
Report by Ciara Ni Driscoll: *Using videos in the Chemistry class*: This initiative looked at the development and use of videos in teaching chemistry to help pupils who missed a class or wanted to recap a lesson. At batch of videos were produced. Pupils accessed the videos, it was reported that a large volume of pupils accessed these videos however no statistics were shown to back up the success of this project

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Activities using Hydrogen Peroxide: This paper focused on three activities using hydrogen peroxide. There were some useful ideas emerging from this paper. It was relevant to current coursework in Junior Cert Chemistry.
Report by Rose Lawlor: General comment: Translation caused some problems in interpreting the papers. *Successful experience in Primary School Science Education*: Primary science project, that looked at micro learning and macro learning in Science. To avoid the problems caused by the abstract nature of the micro pupils took part in laboratory based activities instead. Activities looked at activities relating to solutions. The teachers acted as facilitator of learning. Pupils were encouraged to argue their ideas to come with an answer.
Teaching Chemistry at school: A group fifteen of 15-18 year olds were involved in this project. They involved pupils who were interested in the arts and humanities. The context of the learning was the science in 'Granny's Chest'. The Chemistry, Biology and Physics teacher were involved in aspects that related to them. The Biology teacher looked at the natural dyes in threads, the physics teacher looked at the physics of a spinning wheel and the Chemistry teacher looked polymers and the composition of the threads.
Report by Mairead Glynn: *Digital simulation and experimental activities in physics and chemistry*. Pilot study on the impact of the resource "fusion and boiling points" with level 7 pupils from Spain: The paper looked at a virtual lab where pupils looked at various chemistry experiments. Pupils liked the simulations and felt that it made the Chemistry easier to learn. Results of worksheets showed pupils understood the concept. Initially the pupils were distracted and overly excited but this was gotten around by the facilitators. This paper initiated a discussion relating to the use of Virtual Laboratories and how they could possibly complement the actual laboratory experiences. There was a lot of discussion about virtual laboratories and simulations.
Report by Michelle Herbert: *Planning and Realisation Concept of the Inquiry – Based Science Education in Science Education*: The paper stated on a negative vein listing the problems associated with inquiry based learning. They felt teachers weren't prepared. It did state how useful inquiry was but did little to solve the problems they mentioned for the bulk of the paper. *Pre-school science education in Portugal: teachers education and innovative practices* from the Journal of emerging Science. This report looked at the state of science in pre-schools. It didn't state the resources they were using.
The paper didn't state how they introduced scientific words. It was lacking in finer detail.
Report by Maria Sheehan: *English for Chemistry: FILM BANK*: English for Chemistry aims to provide materials for teaching English for specific purposes. The film bank includes a set of listening comprehension, complementary reading and vocabulary exercises based on a variety of chemistry subjects. One of the main objectives of the project was to improve the quality of specialist vocabulary by using authentic chemistry materials. The paper gives a sample of this material relating to the chemistry of Chlorine. Activities appear to be closed tests where pupils substitute in the correct work in a passage of text. A lot of work has been put into the development of these resources and they have potential to engage pupils and as a result help with the subject specific vocabulary.
Fostering the use of ICT in Pedagogical Practices in Science Education: Fostering the use of ICT in Pedagogical Practices in Science Education (FICTUP) aims to create initiative training materials using ICT accompanied by a close tutoring process. It also aimed to test the impact of the initiative in novice teachers' use of ICT in the classroom. The training materials for this project were developed collaboratively by experience and novice teachers to help with the transfer of knowledge. The resources available are video clips and a pdf explaining the activities associated with each lesson. A large bank of resources have been developed for this initiative. The approach in this project aims to link the Resource Based Learning (RBL) approach with the use of ICT. The papers lists the following contributions as such examples:
Report by James Ring: *Chemistry Education – The Relevance of Innovative Pedagogical Practices in the early years*, a paper by the Portugese partners gave an insight to the Portugese government approach to teaching science and chemistry from kindergarten onwards. The rationale is to make this part of the vernacular, and therefore a subject that grows with the children rather than being forced on them too late.
Teaching Chemistry with a new cooperative model in the classroom – a paper by the Spanish partners – repeats the need for a constructivist approach as already identified by all partners. It also promotes the use of context as a means of making Chemistry more attractive to students.
Report by Michelle Starr: *3D visualization types in multimedia applications for science learning: A case study for 8th grade students in Greece*: The introduction of this paper was really useful in discussing how pupils

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learn. This project developed a multimedia presentation on separation of mixtures. The control group used static pictures. Results indicate that an overall increase in the interest of pupils who were using the multimedia resources. The pupils using the static visuals gave the same correct answers, no evidence suggested that the multimedia activities helped developed understanding. There was cognitive overload for the experimental group as they got to grips with the new methods for presentation of materials.

European ICT survey for schools: The ICT infrastructure in schools is good across Europe. It was reported that ICT was used to prepare lessons however not a lot of ICT is used during the lessons. Pupils use ICT activities at home more often than in school. ICT training is not compulsory for teachers. The report recommends the use of ICT in class, teacher training, and teacher incentives.

Report by Angela Gammell: **Experiences in the laboratory for the gaseous media in the lower school**: This paper looked at activities relating to the mass of air. It was targeted at upper primary or lower secondary. The paper was difficult to translate. Teachers reported that it wasn't feasible to spend so much time on that topic. No facts or figures were reported but students found the activities involved interesting.

Cooperative work in Science lessons: A key but still underused strategy: This paper was very difficult to translate. It reported on an initiative training teachers up in cooperative teaching. The overall conclusion was that cooperative learning was a good thing.

Report by Grace Kenny: *Activity approaches for teaching Chemistry*: EU funded project relating to active learning methodologies in Chemistry. The translation of the paper caused problems. Pupils research their topics and returned to the classroom to take part in more informed debates. Cartoons were used to present chemistry topics.

TALNET- Project for inquisitive youth: Challenges offered to talented pupils relating to Chemistry. No indication to how successful the initiative was. Concerns were raised that it might not encourage pupils to take Chemistry as it is targeting those that would already be interested in Chemistry.

Report by Claire McDonnell: *A Science Teacher Education Course in a Science Centre: A Sucessful Strategy to Empower Teachers to Master Museum Resources Exploration*. This is a novel project. They developed a training course which counts professionally for primary teachers which relates to informal learning in science centres and museums. It consisted of four 4 hour workshops. Results looked at a number teachers and observed visits. It noted an overdependence on workshops, there was also a lack of pre and post work before the visit.

The paper did not make clear how issues raised were addressed.

Chemistry in the Kitchen: This looked at the context of cooking for teaching chemistry. They focused on acids and bases and looked at dilutions. They used historical models for acids and bases. It's a practice based model, pitched at primary school pupils.

Report by David Sutton: *Earth belongs to all of us* – an interschool project on the impact of mineral fertilisers from Bulgarian publications describes a unique approach to a research topic in that there are two separate study groups employed in the research from two different level schools. One school was involved with the theoretical aspect and the other with experiments. The publication suffers from a lack of Chemistry explanation.

A paper from Greece *Exploring the phenomena of 'change of phase' of pure substances using the Microcomputer-based laboratory (MBL) system* is a very good clear and useful explanation of a project using a problem-based learning approach with a practical aspect. Particularly useful is the worksheet employed by the authors which clearly sets out the concept.

Report by Ciara O'Shea: *Some strategies to improve performance in school chemistry, based on two cognitive factors* by Eleni Danili & Norman Reid: This paper looked at two cognitive factors in the chemistry class. It looked at working space memory and their field dependency. They tested pupils for these. Teaching resources were developed to lesson to load on working space memory. These resources related to atomic theory and took a different approach to teaching atomic structure. They used models and dialogue boxes where pupils could clarify the concepts for themselves.

Fluorescence: an Interdisciplinary Phenomenon for Different Education Levels by Spanish authors J.A. García, J.M. Moreno, F.J. Perales, J. Romero, P.Sánchez, L. Gómez Robledo: This looked at how you could teach everyday concepts using florescence. They looked at applications, health education and got pupils working groups. They worked with primary school pupils.

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Workshop members broke into groups and discussed how they have used materials available on the portal:
Group 1: School level – Primary
Area of syllabus: Changes of state.
Resource used: www.planet-science.com
How resources are used: The website listed above includes videos as stimulus to engage, interactive games relating to the concepts and suggested activities to develop the concept of changes of state at primary level.
Group 2: School level – Upper secondary
Area of syllabus: Environmental Chemistry (water, pH, acids and bases, atmospheric chemistry)
Resource used: www.chemsitry-is.eu (Chemistry and the Environment)
How resources are used: The website listed above includes videos, multiple choice question quizzes, useful links to other resources and instructions for practical activities to enhance the teaching of the concept.
Group 3: School level – lower secondary
Area of syllabus: Atomic structure and Periodic table
Resource used: 50 really cool online tools for science teachers & www.scienceunleashed.ie
How resources are used: atom builder, sub atomic particles, uses of the different elements, Salk's periodic table on the portal is very useful.
Each group presented the resources they would use and put them in the context of a lesson sequence.
This activity was followed by a general discussion on resources and successful experiences. Once again the RSC Learn Chemistry portal was cited as being a source of a myriad of resources for all levels and teaching approaches. The precursor project *Chemistry is all around us* with its teaching units was once again praised for its content. The comparison in terms of attractiveness of the two portals was noted.
Some of the teachers spoke about the reactions of their students to particular resources. Marie Walsh has gathered surveys from students and teachers that will be summarised at a later date. The meeting ended with the collection of the portal evaluation questionnaires. The portal scores an average 7 for most aspects. There is some frustration around translation and also currency of the items listed. There is observed diversity in the length and relevance of resources. It is an on-going issue that the portal could be more successful in imparting its huge accumulation of material if it were more attractive and interactive. The advertisement of a conference that happened last November (2013) should not be a feature of the main page.

4.3 Successful Experiences: testing the realities

In relation to the different issues which have been discussed in relation to language, a number of first year undergraduates studying an introductory Chemistry module were surveyed.
The survey results show that of the 74 respondents, only 30 have studied Chemistry to Leaving Certificate (upper secondary school level), even though they are on one of a suite of degree programmes with Chemistry as a core subject. Twelve of the students are over 23 years of age, i.e. 'mature' students.
English is not the first language for nine students. The primary languages are French (3), Lithuanian (1), Somalian (1), Arabic (1), Persian (1) and Polish (2). There is one deaf student with an interpreter.
Forty nine students have started compiling a glossary, as advised at the start of the class year.
Moodle is the Virtual Learning Environment platform used in Limerick Institute of Technology. For the Chemistry module the content includes lecture notes, links to relevant websites and video clips. These are sectioned by topic. Only two thirds of the students regularly use Moodle, even though it is a primary source of back-up material for lecture and laboratories.
The plan from now is to initiate the E-glossary idea for these students by setting an assignment. There will also be trials of different initiatives based on the successful experiences reported by other educators. The assignment has been administered but the e-glossary will form the basis of work for the new intake of students in Autumn 2014.

4.4 Testing of Resources

Some teachers participating in the project undertook to test specific resources with their students. They are doing this on an on-going basis and their comments are being recorded in the relevant section of the portal. Interestingly the junior students love the resources but the more senior, exam-focused students prefer their exam-focused text books and notes and find the interactive resources interesting but distracting from their

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examination preparation. This is not necessarily a negative aspect, as it is the younger students we want to attract to Chemistry in the first place.
The testimonials of the teachers are informative:

For the past two years I have used the resources available on the Chemistry Is All Around Us network portal. There are several elements to the portal that a teacher may find useful. First and foremost the teaching resource section; in this section of the portal you can use the search engine to find useful software, worksheets or websites to aid you when teaching a topic at a particular level. The search engine helps to narrow down the appropriate resources. Although it may take a little bit of time to look though them, you will always find something that will make learning more interactive and exciting.
Personally, 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

I have found the Chemistry All Around Us Network an excellent project to be involved in, I am not teaching senior chemistry but I am involved in junior chemistry. I have found some of the interactive resources very useful in my junior classes – and my students loved them.
I have chosen to review the more biologically-slanted papers to review – and have found them imaginative and interesting. It is always very useful to see how other countries do things.
The variety of papers and resources is immense.
I have especially enjoyed the opportunity to meet with and discuss issues with other like-minded science teachers/experts – a very important element of life-long learning.
I feel I must mention that it is unfortunate that the translations of some papers do not do them the justice they deserve. Rose Lawlor

I feel there were two benefits in being involved with the European project. Firstly, I feel that I have learned many things from my colleagues in Ireland. We have discussed the Irish system and the difficulties in teaching certain aspects of the Chemistry course and I have tried many new techniques that have been suggested.Secondly I have been made aware that these difficulties are not unique to Ireland and the problems arise across Europe. I have been very interested in how others have tried to overcome these difficulties.
Diane Condon

5. Conclusion

Successful Experiences in Chemistry teaching and learning arise from: Understanding and managing difficulties with language; Understanding the skills levels of students; Placing Chemistry in a multidisciplinary context; Active learning and Inquiry-based strategies for teaching and learning; and technology used well can enhance the teaching and learning process. It is not possible to trial all of these modes at one time but a combination of these could be implemented to observe their impact on the learning experience of students. The intention of the author is to qualitatively measure the effects of some initiatives, in particular the E-glossary, on the learning outcomes of a group of Chemistry students. This will be reported in the context of the final phase of the Chemistry is All Around Us Network Project.
Meanwhile it is evident that children need to learn to appreciate Chemistry from the earliest stages of their education. While Chemistry is implicit in the primary science curriculum in Ireland it is not explicit. The word 'Chemistry' does not appear. When it does appear at secondary school level it fronts abstract ideas about the nature of matter and the elements and great efforts have to be made to endure that its relevance matches that of the more natural ideas of Biology and more intrinsically relevant Physics. If teachers do not have sufficient Subject Content Knowledge as well as Pedagogical Skills Training they are prone to misconceptions which they perpetuate in their teaching. A well trained teacher who is enthusiastic for the subject can make all the difference in attracting the student to the subject and imparting confidence in their understanding of complex and abstract ideas.
The database of resource collected in this project has given a foundation for teachers and their students to deepen and broaden their knowledge and appreciation of Chemistry and for that it is applauded.

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This project has been funded with support from the European Union.
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