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STEM Teacher Education – Initial and Continuing Professional Development

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DCU

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WELCOME ADDRESS

We, the organising committee of SMEC 2016 would like to welcome you to Dublin City University for this conference entitled *STEM Teacher Education - Initial and Continuing Professional Development*.

SMEC 2016 is the seventh in a series of biennial international Science and Mathematics Education Conferences to be hosted by CASTeL – the Centre for the Advancement of STEM Teaching and Learning. The purpose of this conference series is to provide an international platform for teachers and educators to discuss practices and share their experiences in the teaching and learning of mathematics and science. Previous conferences have focused on themes such as Inquiry-based learning: Assessment in Science and Mathematics; Facilitating authentic learning experiences in science and mathematics; Sciences serving science; and Exploring the interconnections between teaching and learning of mathematics and science.

SMEC 2016 focusses on teacher education in STEM. Papers are presented in the areas of:

- Initial teacher education; including professional knowledge of teachers; teaching and learning in initial teacher education; relating theory to practice; and issues related to teacher education programs, policy and reform;
- In-service education; including in-service education and training; curricular reform and new programmes
- Continuous professional development for all teachers; including teachers as lifelong learners; methods and innovation in professional development; evaluation of professional development practices; and reflective practice, teachers as researchers, and action research.

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Intervention-based research in (mathematics) teacher education

Andreas J. Stylianides

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Teacher education research in mathematics and other subject areas has focused more on documenting important and persistent problems of prospective teachers' subject knowledge (including subject-related beliefs) and less on designing interventions to generate promising solutions to some of these problems. In addition, virtually all available interventions have long duration, thus appearing to imply that these problems can only be addressed by lengthy instructional treatment. While any promising solutions to important and persistent problems of prospective teachers' subject knowledge are welcome, I ask whether "quicker solutions" might also be possible. Indeed, if effective instructional interventions of short duration were possible, it would be easier for researchers to tease out their theoretically essentially components and more practicable for teacher educators to use them in their courses. In this talk (1) I will argue the need for more research on the design of interventions of short duration that can help alleviate important and persistent problems of prospective teachers' subject knowledge and (2) I will draw on findings from a 4-year design experiment in a mathematics course for prospective elementary teachers to present suggestive evidence for the possibility of designing such interventions.

Assessment for learning: Resources for first year under graduate mathematics modules

Caitríona Ní Shé[1], Sinéad Breen[2], Connor Brennan[1], Frank Doheny[3], Christine Kelly[5], Fiona Lawless[4], Ciarán Mac an Bhaird[5], Seamus McLoone[5], Eabhnat Ní Fhloinn[1], Brien Nolan[1] and Ann O'Shea[5]

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There is general recognition that many students are underprepared for the mathematics modules they encounter in first year undergraduate courses (Lawson et al. 2012; Faulkner et al. 2010). This project, funded by the National Forum for the Enhancement of Teaching and Learning (NFETL), aims to develop technology enhanced formative assessment resources that will improve the teaching and learning of mathematics in first year service mathematic modules.

The first phase of the project identified common problematic concepts and procedures, the types of resources students use and those resources recommended by lecturers (Ní Shé et al. 2015). In the second phase we developed technology enhanced resources and trialled them within 1st year undergraduate mathematics modules. We are currently evaluating the resources in order to improve them prior to dissemination to the Higher Education Institutes in Ireland.

A number of different resource types have been developed across the institutes; Khan Academy Playlists; Student screencasting; Audience Response System; Interactive Geogebra tasks and Moodle Lessons. Each of these resources was trialled in one or two of the project institutes during the academic year 2015/2016 and initial evaluations have taken place. In this presentation we will focus on a description of the types of evaluations used and the preliminary results of these evaluations. We will also give a brief description of the overall project.

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Investigating students' difficulties with differential equations in physics

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There are numerous cases in physics where the value of a quantity and changes in that quantity are related. For example, the speed of an object depends on its acceleration; the radioactivity of a sample depends on the amount of the sample present. Except in highly idealized settings, the analysis of these cases requires students to recognize, set up, and solve a *differential equation* (DE).

In many universities, including DCU, DEs are studied in mathematics before they are applied in physics. However, the aims of mathematicians and physicists can be very different. Mathematics modules emphasize the classification of DEs and their theoretical aspects (questions of existence and uniqueness of solutions). Techniques for solving DEs are also studied. In physics modules, modelling is emphasized: students must apply mathematical knowledge to interpret a setting, recognize the need for and set up a DE, solve it, and interpret the solution.

This talk addresses research being carried out on the identification of difficulties encountered by physics students studying differential equations and the development of an intervention to address these difficulties. A survey was given to students after completing an introductory module on DEs to assess their understanding of key concepts and procedural competence. The survey was divided into four sections (Prior mathematical learning**;** Conceptual issues in the study of differential equations; Transfer issues; and Modelling) and provided a broad look at the students' abilities having completed this module. An intervention (a set of tutorials to be ran alongside future iterations of the module) was designed based on the results of the survey as well as the relevant literature, and has been trialled.

The survey, its results, and the intervention will all be discussed as well as the theoretical perspective adopted for this project, APOS theory (Dubinsky 1984), and the module the project is focusing on.

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Integrating mathematics into science: Collaborative curriculum design

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This paper will describe aspects of a pilot trial of exemplary curriculum materials that integrate mathematical practices into science. Mathematical practices are an integral aspect of the scientific practices that, along with scientific knowledge, constitute the discipline of science (Irzik and Nola, 2011). These are, however, often neglected in the second-level classroom (Osborne, 2014). The exemplary integrated lesson units are based on the Irish lower second-level (Junior Cycle) curricula for science and mathematics, and were developed as part of a previous research project (Walshe, 2015). They are structured on a model designed to support teachers to develop their own integrated mathematics into science curricular materials. In the pilot, the exemplary integrated units will be implemented into the classroom in order to evaluate their impact on student learning and attitudes to STEM. The first step will be a collaborative design workshop in Autumn 2016 for the teachers involved in the pilot, with the aim to adapt the exemplary lesson units for teachers' local circumstances, and their students' needs, utilising the curricular model. Teacher participation in curriculum design helps ensure successful implementation of curricular change, because it supports the development of more robust curricular materials and promotes teacher ownership of change (van den Akker, 2013). This paper will elaborate on the revisions to be made to the exemplary integrated lesson units, based initially on the feedback given by 17 science teachers in the previous research cycle, and in the light of the new Irish Junior Cycle science curriculum. It will outline the design of the collaborative teachers' workshop. It will present some implications of involvement in curriculum design for all curriculum stakeholders, including teachers, and will indicate how these have shaped the pilot project.

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Initial science teacher education on nature of science: A family resemblance approach

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Evident from its inclusion in curricular documents both nationally (NCCA 2015) and internationally (NGSS 2013), Nature of Science (NOS) is winning a place in science education and science teaching. Considering its recent inclusion in the Irish lower second-level science curriculum, tackling NOS is a concern for initial science teacher education programmes in Ireland, as it will be pivotal to its successful incorporation in the science classroom. To address NOS in initial science teacher education programmes, a two-phased voluntary study is underway. Debates around exact NOS elements that should be the focus for inclusion are ongoing (Erduran and Dagher 2014, McComas 2004); therefore to frame NOS, this research is underpinned by the theoretical framework of the Family Resemblance Approach (FRA) (Irzil and Nola, 2014, Erduran & Dagher, 2014). The FRA assumes a comprehensive and systematic approach and provides a novel way of capturing the unity of science while doing justice to its diversity (Erduran & Dagher, 2014). The study utilises recognised models for teacher education, namely Shulman (1987), where it is envisioned that it will develop science content knowledge, pedagogical content knowledge, curricular knowledge and NOS content knowledge, all shown to aid in effective teaching and learning (Abd-El-Khalick and Lederman 2000, Lederman *et al* 1992, Shulman 1987).

The first phase of the study has been recently completed. It involved the design and facilitation of a purpose built programme consisting of six two-hour workshops each week for pre-service science teachers. The workshops aimed to develop (i) the pre-service teachers' NOS content knowledge through the FRA model, (ii) materials for their classroom and (iii) their knowledge of the new Junior Cycle Science specification. The second phase will shadow the pre-service science teachers into the classroom and explore how they incorporate NOS into their science lessons.

There were a number of data collection points for evaluating the impact of FRA as a model for NOS conceptual development. Phase one includes completion of a questionnaire specifically designed around FRA, for both pre- and post-testing, digital recordings of the six two-hour workshops and interviews with the pre-service teachers upon completion, artefacts generated by the pre-service teachers such as assessment questions, concept maps, activities completed during the workshops. Phase two of data collection will include digital recordings and written observations of lessons, post-lesson interviews, delayed post-testing with the FRA questionnaire and artefacts from their teaching practice.

Preliminary findings indicate that the pre-service teachers displayed degrees of conceptual change around a range of NOS ideas they had previously held, as evident from the pre- and post-test. Following the workshops, all stated they had greatly changed their perception that science is "*clean cut, black and white*", and in how they now see science in their own learning and future teaching. Fullan (2001) states that educational change is slow and takes time, so indication of conceptual change after a comparatively short period of time is a good indicator of the impact of this model for increasing pre-service science teacher conceptions of NOS.

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Teacher-based curriculum development incorporating nature of science in Irish junior cycle science

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This paper presents an overview of a project which will be beginning in the University of Limerick in September. This project is focused on providing professional development for teachers for the practice of Nature of Science (NoS) in the science classroom. In its totality, NoS reflects how science is practiced in the real world and includes understanding about how scientists work, how to investigate in science, how to communicate in science and how to understand the role of science in society. This project is built on the Family Resemblance Approach to NoS framework designed by Erduran and Dagher (2014). NoS is set to be a unifying strand in the new Junior Cycle Science Specification (NCCA, 2014); however international data purports teachers' understanding of NoS to be low level (Alswelmyeen and Al olimmat, 2013). Therefore provision is needed to help teachers develop their own educational theory of NoS. This project therefore places itself as a pilot study to understand the needs of teachers in such professional development experiences. This paper will discuss the project goals as well as the use of a localised professional learning community (PLC) to facilitate professional development. A PLC is effectively a learning environment where those within it support each other as they construct new knowledge (Lewis et al, 2014). The use of PLCs has stemmed from previous work involving the primary author and therefore reflections are made concerning how such communities can provide for authentic learning experiences. The use of learning communities is also echoed in the literature as a vehicle to enhancing teachers' perceptions of NoS (Lewis et al, 2014) by focusing on developing their self-efficacy with respect to changing practices. This professional development will take the form of workshops as well as in-school support for teachers (n=9 from the Limerick Region). Reflections are again made on how in-school support may facilitate teachers professional development. Resources will also be provided by the researchers and will reflect practical examples of how NoS can be placed in the science classroom . The project aims to answer two key questions around NoS, namely: (RQ1.) What are the perceptions of teachers of NoS prior to and after a professional development experience? (RQ2.) How does the provision of professional development opportunities enhance teachers' practice with regard to NoS?

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Teaching Numeracy as a cross curricular subject in post-primary school

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This paper provides a review of literature on key issues in numeracy at post-primary level focusing on policy framing, definitions and teacher knowledge. At present, internationally and in Ireland there is a conscious effort being made to improve and raise the profile of the teaching and learning of numeracy (Goos et al 2010; DES, 2011). In November 2010, the Minister for Education in Ireland ascertained that Literacy and Numeracy are skills that every person should develop fully in order to meet the demands of everyday life.

While the policy prioritisation is evident, there are many issues surrounding the teaching and learning of numeracy in schools that pose significant challenges. From a policy perspective numeracy is increasingly seen as an important, if not essential, component of all teachers professional remit. A significant challenge at both the levels of policy schools, especially secondary schools, is the issue of defining numeracy. For example, how do teachers perceive or understand the term numeracy? Differing perceptions often revolve around the common misconception that teaching numeracy is solely the role of teachers of mathematics. Increasingly in various jurisdictions (e.g. Australia, [AATM, 1997]; United States of America, [Steen, 2001]), including Ireland (DES, 2011), teachers of all subject areas are being charged with the responsibility of teaching numeracy. Thus, governments, researchers and policy makers world-wide are encouraging numeracy to be taught across all subjects. In order for this to be implemented effectively, it is essential that the teachers have a deep understanding of the numeracy in their subject area, that is, the issue of where numeracy resides in terms of teacher knowledge frameworks.

Contemporary Science in chemistry teacher education – the conception of an empirical study

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Students who are going to be chemistry teachers in Germany often don´t study chemistry in such a depth in relation to current research. This is sometimes advocated by the fact that school curricula seem to reflect the status of chemical knowledge up to the 1950s. By contrast, new teaching strategies such as a 2008 study shows that the higher the expert knowledge is, the higher the skills for teaching are. Our research project therefore focuses on the professional development of chemistry teacher students in relation to today's chemistry research. The main question of this empirical study is: Does the professionalism of students studying chemistry education change if they are confronted with today's research?

To answer this question the study is developed on the theoretical basis of Shulman's concept of teacher professionalization, with a focus on Subject Matter Content Knowledge and Pedagogical Content Knowledge, including a third dimension, that of Beliefs. The three categories will be examined under consideration of the competence-orientated theory.

This study follows a mixed methods approach of quantitative methods (questionnaires, tests) and qualitative methods (interviews, discussions, videography) which will be combined to create a wider foundation. The research design allows for the collection of data to be passed through six times within in a period of three years. The poster will show the genesis and the structure of the research project, give an insight into the test instruments and the concrete categories of the qualitative analysis and include first impressions of the tutorial.

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Engaging Students in Pedagogic Research and Teaching Enhancement in Tertiary Science and Mathematics

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The PRiSM (Pedagogic Research in Science and Mathematics) brings together academics who are engaged in pedagogic and educational research in Mathematical and Physical Sciences, with a focus on action research, to inform teaching practice and curriculum design.

A key feature of PRiSM is to develop research in teaching enhancement working in partnership with undergraduate students. A number of summer student scholarships were awarded and also final year projects were undertaken across the faculty, at Leeds and Birmingham. There are many benefits to all parties in engaging students in pedagogic research within their disciplines. Students gain a greater insight into the development of teaching and learning, a student perspective is embedded within the development of Teaching & Learning, students gain valuable transferable skills and the scheme wholeheartedly embraces the philosophy of "students as producers." Additionally, undergraduate and postgraduate students were actively involved in the creation of new context and problem based learning resources, taking on authorship of sections of the resources. Engaging students in such activities ensures a student perspective is at the heart of their creation, whilst providing an excellent development opportunity for the students.

A number of recent project findings will be presented, particularly focusing on Chemistry, Physics and Mathematics. The benefits of engaging students in teaching enhancement and pedagogic research, and what the outcomes of the projects have been, in terms of benefiting the whole student population in the school will be discussed.

Whilst the concept of summer internships is not a new idea, the development of teaching enhancement/pedagogic research internships is more novel. One of the key strengths of the scheme is that students from across different disciplines have had the opportunity of working together to enhance the activities that will take place in the various schools in the future, allowing for cross-fertilisation of ideas. In addition, as members of PRiSM, practicalities such as obtaining ethical approval could be dealt with more effectively and quickly.

Curriculum development- teachers as active agents of change

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Ireland has followed international education policy trends, and is currently engaged in a period of considerable curricular change, particularly at second-level. Recently revised Leaving Certificate science curricula in Ireland show a number of similar policy trends including: a move from the explicit specification of content towards a more generic, skill-based approach; a greater emphasis on the centrality of the learner; and greater autonomy for teachers in developing the curriculum in school (Siennema & Aitken, 2013). The constructive forms of pedagogy associated with these curricula encourage the development of deep learning (Biesta, 2014).

New subject specifications in Ireland are being written in terms of learning outcomes, into which development of key skills, and flexibility of teaching and learning are built in. The move to learning outcomes requires teachers and the system to move away from a linear view of curriculum to a 'multi layered process of knowledge being constructed, with numerous influences at work at every level from the national system to the individual learner' ((Daugherty, 2006). Teachers will have to look deep into learning outcomes and unearth the complex non-linear interactive system (ibid), so that they can ensure a coherence between curriculum, pedagogy and assessment.

This paper describes how the NCCA worked with science teachers to design educative curriculum support materials intended to promote teacher learning in addition to student learning. The materials build from important parts of a teacher's knowledge base: subject matter knowledge, pedagogical content knowledge for topics, and pedagogical content knowledge for disciplinary practices. Educative curriculum materials serve as cognitive tools that are situated in teachers' practice (Davis & Krajcik, 2005).

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Educational policy reform documents: 'Oughtering' the designated identities of mathematics teachers

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Teacher professional identity can be envisaged as a dynamic construct shaped by, and shaping of, the structural and cultural features of society, school and classroom. Seen in this way, teacher professional identity is viewed as a discursive construct that can be expressed through stories. Policy documents are also discursive productions circulating the dominant discourse within a particular context and have the capability to construct, - that is to afford and/or constrain, teacher professional identities. In this article, a narrative perspective on identity is employed. The relationship between narrative and identity is much discussed in the literature, highlighting narrative as a viable theoretical base for researching teacher professional identity. Thus, for this study, teachers' professional identities are equated with their stories – be they narrated by teachers or others. Adopting Sfard and Prusak's (2005) definition, teachers' actual identity consists of the stories told about the current state of affairs, while teachers' designated identity comprises the stories expected to be told in the future. Critical Discourse Analysis (Fairclough et al. 2011) was employed to examine the construction of the actual and designated identities of teachers in a pivotal post-primary mathematics educational policy document in the Republic of Ireland i.e. Review of Mathematics in Post-Primary Education: a discussion paper' (NCCA 2005). Findings indicate that this document articulates a narrative of Irish post-primary mathematics education. The analysis demonstrates that this narratives plot may be to 'oughter' the designated identities, counterpointed against the perceived actual identities, of post-primary mathematics teachers in the Republic of Ireland.

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Student teachers' identity perceptions in the beginning of professional practice: Pre-service versus in-service

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Learning is the result of a singular and social adaptation process of personal ideas and beliefs. Therefore, initial teacher education (ITE) plays an important part in promoting reflection and professional development. This paper is part of an ongoing PhD study funded by FCT (SFRH/BD/111488/2015). Having the higher education area at heart, with this comparative research our goal is to understand how ITE of science teachers is done in two European higher education institutions (the Institute of Education of the University of Lisbon, in Portugal, and an Irish institution). We intend to comprehend in what way the ITE curricula (that confer teaching qualification for secondary science teachers) of these two institutions embody the European guidelines, and how the professional practice (school placements) influences the professional identity perceptions of student teachers. In this paper we will focus our attention in the student teachers' identity perceptions in the beginning of their final school placements.

Using a qualitative methodology of case study research, we are currently following, in Portugal, the development of four final science student teachers throughout their school placements. Before beginning their practice, these student teachers were asked to write a narrative about their perceptions on school, teachers, students and teaching. Then, the classes they taught, during their school placements, were observed. Next, they (and their supervisors) will be interviewed. This last step of data collection has not yet been done. These data will help us understand how these student teachers develop their professional identity perceptions through the contact with professional practice.

Currently, in Portugal, to be able to teach one must have a teaching qualification. On the one hand, we have the (young) people that have never taught, but who have a passion for teaching and want to become teachers – the pre-service (student) teachers. On the other hand, we have the teachers that already have years of teaching experience, but do not have the required teaching qualification – the in-service (student) teachers. All of the above are together in the same ITE programmes.

Based on the preliminary analysis of the student teachers' written narratives, and on the preliminary analysis of the observations of their performances, during the first classes they taught in the beginning of their final school placements, we will compare their identity perceptions. This will show that there are noteworthy differences between pre-service and in-service student teachers, with the latter having greater awareness of their performances and identities. However, pre-service teachers show the ability to reflect on their practices by mobilizing scientific and pedagogical knowledge.

Student teachers' experience of reflective practice in the mathematics classroom

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As part of reform in initial teacher education (ITE), the Bachelor of Education degree (B.Ed.) was reconfigured to include a fourth year of training (DES, 2012). Revised programmes of study were required to put "a greater focus on the development of teachers' research skills so that, once qualified, they can use educational research to inform their day-to-day work" (Harford, 2016).

Church of Ireland College of Education (CICE) students have always had the option to engage in an additional year of study in order to qualify for an honours degree with the completion of a research project being a compulsory component. Contrary to perceived expectations that students would struggle with this additional workload on top of working full time and studying part-time, research indicated that the process of being engaged in inquiry, sustained early career teachers and supported efficacy and resilience (Halpin et al, 2015).

We will share sound bites from two final year and two newly qualified teachers (NQTs) on their experience of having the "opportunity for rigorous, systematic practice-oriented inquiry" to help them understand their own professional development "through critical reflection on their emerging thinking and practice" with regards to teaching mathematics in the primary school classroom and involving parents in their child's mathematical learning (Harford, 2016).

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Understanding the interactions between pre-service science teachers within a learning community focused on enhancing scientific inquiry orientations

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This paper reports on the interactions between a cohort of Irish pre-service science teachers (PSTs, n=12) as they engaged in a professional learning community (PLC) focused on enhancing inquiry orientations. This PLC involved using an existing PCK lens to foster and develop inquiry orientations. This tool, known as the content representation (CoRe) tool was originally developed by Loughran *et al.* (2006) but has since served many purposes to others in the research community. It was originally developed to make explicit the often tacit nature of PCK and as such it captures and portrays the topic-specific PCK of teachers. A CoRe is viewed as a heuristic device within the relevant literature (Loughran *et al.* 2006). It is essentially an interview tool, the result of which is a tabularised documentation of participants' PCK through group articulation.

The CoRe was adapted in phase two of the study to have a greater inquiry focus after findings from phase one reported limited reference to inquiry in the PSTs' collaborative dialogue. Despite its uses in a variety of contexts, the CoRe tool has yet to be used to capture and enhance inquiry orientations. The dialogue during the CoRe development was transcribed and analysed through discourse analysis and this, together with semi-structured interviews was used to capture the interactions between the PSTs involved in the PLC. The findings report on the initial contestations, tensions and challenges experienced by the PSTs as they engaged in this PLC but also illustrate the changing interactions between the PSTs through group collaboration. In all it looks at how a cohort of pre-service science teachers socially constructed their knowledge of inquiry by inquiring into their own practices. These findings suggest that the CoRe tool can be used to foster and develop inquiry orientations within a dedicated learning community. The findings also intimate that the act of engaging in such collaborative dialogue is something which may take careful scaffolding and time but can lead to professional development opportunities as PSTs explore their understanding of inquiry.

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CPD strategies for teachers and scientists in higher education

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Scientists have had a role in higher education since the very first institutes of higher education. While this role has evolved considerably in the last century, the period that has seen the most significant changes has been the last four decades. The rapid expansion of the higher education sector and the massification of education through the commitment of the state to free education have seen the role of scientists in higher education in Ireland swell to incorporate new responsibilities and expectations. In this paper a brief history of the role of scientists in higher education and the recent changes to that role are presented. Although these changes are focused on the role of Irish scientists, similar changes can be identified across Europe. A new strategy for supporting scientists in higher education is proposed — a research-informed Masters programme in science education that provides the necessary skills and experience for early career scientists in higher education to cope with the demands of their positions.

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A CPD programme for out-of-field mathematics teachers: Programme outline and preliminary evaluations by participants

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This abstract outlines an innovative Continuing Professional Development (CPD) programme established in Ireland for out-of-field mathematics teachers in second-level education. Research on out-of-field mathematics teachers in Ireland conducted by Ni Riordáin and Hannigan (2009) motivated the development and implementation of a unique two-year, part time Professional Diploma in Mathematics for Teaching (PDMT).

The programme was first offered in 2012 jointly by the University of Limerick (UL) and the National University of Ireland Galway (NUIG) and to date, there have been 528 graduates of the PDMT. This university accredited (Level 8) diploma is currently in its fourth year and a fifth cohort of students has been approved by the Department of Education.

The PDMT was designed and implemented by the National Centre for Excellence in Mathematics and Science Teaching and Learning (NCE-MSTL), now the National Centre for STEM Education (EPI·STEM) based in UL. This unique programme was specifically designed to upskill post-primary teachers who are currently teaching mathematics, but whose teaching qualification does not include mathematics. The programme is delivered nationally in a blended learning mode through local nodes in partner institutions located throughout Ireland, in face-to-face and/or online modalities.

There has been a trend in the field of CPD towards a greater emphasis on needs identification (prior to the CPD event) and evaluation and follow-up (after the CPD event) (Craft, 2002). The PDMT was specifically developed to address the national need to upskill out-of-field mathematics teachers and for each cohort of teachers enrolled in the programme, participants were asked to complete an online evaluation of the programme after completing their first of two years.
In this paper, initial findings relating to participants' evaluation of the PDMT are outlined, and strengths and weaknesses of the programme are identified.

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Helping Teachers to Teach Coding

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The School of Computing at Dublin City University (DCU) has run the ComputeTY programme for Transition Year (TY) students (15 – 17 years of age) for over 10 years and it has been very successful. One of the most popular modules is the AppInventor module which involves the students developing their own apps using AppInventor. This project involves the shrink-wrapping of the AppInventor module so that it can be delivered on-site in both primary and secondary schools all over Ireland without the need for the students to travel to DCU. The project also involves developing a mini-MOOC in order to train the teachers to be able to deliver the course themselves and workshops to enhance the participants' Community of Practice (CoP). The Professional Development Service for Teachers (PDST) is involved in the design and will be a key player in the dissemination of the course amongst teachers.

The objectives of the project are:
• to deliver a computer programming module suitable for schools that each individual school can deliver to their students in a way that suits their particular circumstances
• to train teachers to be comfortable, competent and confident with delivering the module in their own school
• to disseminate our AppInventor resources to schools across Ireland so that students who cannot attend on-site in DCU, can avail of the resources

This project is being funded by Google under the CS4HS (Computer Science for High School) initiative.

Massive Open Online Coding: Exploring the role of MOOCs for post-primary computing education in Ireland

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MOOCs are now gaining significant attention as a potential vehicle for helping facilitate the continual professional development of teachers (Laurillard, 2016). As MOOCs are deployed or utilized towards the less formal end of learning spectra we can see that many issues that can bedevil MOOCs are diminished. For example credentialing and completion are less important for a teacher who may dip into MOOCs, sample the wares and take home combinations of ideas and inspiration in the manner of a bricoleur (Strauss, 1966). Moreover, the teacher is already degree qualified, digitally literature and more generally competent in navigating a learning environment with little formal support. It is hence timely to examine the current role of MOOCs in computing education of post-primary/k12 teachers (Vivian, Falkner, & Falkner, 2014; Settle, Vihavainen, & Mille, 2014) in the context of the introduction of the new junior cycle short course in coding in Ireland.

Another possibility MOOCs present is to help teachers more directly by having the students themselves enrol (Kurhila & Vihavainen, 2015). In this way teachers may be supported in guiding students through a new curriculum that requires much teaching by doing and which, being in its infancy, does have a strong foundation of supporting resources. This model poses challenges however as we can say that the learners involved have much less formal educational experience, are minors and may require very different supports than older more educated learners (Guzdial, 2014).

This paper will explore the issues involved in both MOOCs for continuing professional development of teachers of computer coding and also the possibilities for junior cycle students themselves. Relevant current initiatives will be critically discussed with an eye to potential impacts and future directions.

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Patterns of discourse in pre-service teachers' explanations

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The construction of explanations is key to creating new knowledge (Osborne & Patterson 2011). It is therefore important that pre-service teachers (PTs) are provided with opportunities to explain scientific phenomena as part of their initial teacher education. This study investigates the patterns of dialogue that took place while a group of PTs constructed a scientific explanation about a tanker imploding. A group of 4 PTs discussed what might have happened to cause a tanker to implode after they had watched a short video clip of the event. The group were encouraged to discuss what was happening, along with drawing a poster outlining what they think happened. PTs were occasionally questioned by the authors during the course of the workshop. The group's conversation was recorded, and the 51 minute conversation was transcribed.

Initially an analysis of the dialogue was undertaken using a Toulmin Argumentation Pattern (TAP) framework (Erduran et al, 2004). While we did find that argumentation was part of constructing explanations, this framework alone did not give an accurate account of the dialogue, as other types of discourse that take place in the science classroom were more prevalent. Therefore, we explored an analysis of the discourse combining TAP (Erduran et al, 2004), sense-making (McDonald and Kelly, 2012) and transactive discussions (Kruger and Tomasello, 1986).

This presentation outlines the type of analysis undertaken, and discusses the patterns of discourse that took place in the workshop. It will also discuss how the study contributes to a wider design based experiment exploring the Professional Vision of PTs.

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Using physics and technology in mathematics lessons to encourage a growth mind-set

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This action research project investigated the use of ICT equipment, normally associated with the Physical Sciences, to: facilitate the aims of Project Maths; foster a greater appreciation of the links between Maths and Physics; and to promote the development of a growth mind-set. As part of the research process 10 students participated in a series of lessons primarily centring on Functions and Calculus, while involving other strands of the Project Maths syllabus. The main findings showed that the use of ICT equipment associated with Physics: (i) heightened student awareness of the use of mathematics in tackling real world problems, (ii) allowed learners to see the connections within mathematics and between mathematics and other subjects, and (iii) generated a greater enthusiasm for searching for creative solutions among students who already had an essentially growth mind-set.

Progress and difficulties in student's understanding of vector and field concepts in electrostatics: A qualitative study of a small group of upper secondary students

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Electrostatic fields are abstract models, used to describe the behaviour of the interactions of charged bodies. There are many individual tools that students can use to explore concepts involved in electrostatics, such as vector representations, field lines and mathematical reasoning. Giving students the opportunity to master all these tools equips them with better opportunities to fully interpret and predict the behaviour of charged bodies.

In this talk, we present a small body of research completed with a small group of students (N=7), understanding a 2 year course in upper secondary Physics. The background research, methodology and findings from previous studies are discussed. Examples of the student's progress in development of the concepts related to electrostatics are presented, and difficulties encountered by the students are discussed. Our discussions detail possible sources of difficulties encountered by the group, and suggest activities going forward to help future student group overcome such difficulties. Our conclusion illustrates the process of development of the educational material from conception to implementation, under the lens of an enquiry practitioner, undertaking action research.

Learning with optical blackbox-experiments

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Blackboxes are a specific type of an experimental task and well-known in competitions and education at college or university level. The inner part of a blackbox is unknown and has to be investigated by changing inputs and interpreting the observed outputs. It may happen that a model of the inner structure of a blackbox is not unique (Burkert &Rudolph, 1974; Fischer 1971) and cannot be determined without opening the box. Dealing with blackboxes contains aspects of Nature of Science, too. While electrical blackboxes are discussed quite often, mechanical or optical blackboxes are investigated rarely. Nevertheless, they are used in our group widely in science education and professional development courses as well as in research projects in the context of problem solving activities (e.g. Bunder et al., 2006).

A sequence of optical blackbox experiments was developed for regular physics classes in lower secondary school (Friege & Rode, 2015). In a pre-post-test design learning with these experiments was investigated as well as motivational effects. (N=250; Rode, 2016). Usability and difficulty of the blackboxes, quality of instruction and students' motivation have been in focus. Surprisingly, there was a gap in the motivation between these young female and male students in the pre-test and an unexpected strong increase in the motivation of the female students resulting in a closed gap in the post-test.

In a follow-up study we repeated the test design with older students (8th & 9th grade, N≈100) to check an age effect on the motivation. Using pre-post-test design, content knowledge, personal data, and motivation were measured using paper-and-pencil tests. The investigation was conducted in two periods of 90-minutes units. After short introduction in plenum the blackbox experiments (unit 1: mirrors only, unit 2: mirrors & beam splitters) were solved in pairs of two students with the same gender. A written documentation for each box was drawn up by both pupils.

Tested instruments were used as far as possible. To get access to pupils' motivation, the boxes' difficulty, and given instructional framework, the survey used by Mezes, Erb &Schroter (2012) was used slightly modified. The related five-point-Likert-scales covers interest and fun, feedback, expecting success, and flow.

Another follow-up study is concerned with a comparison of two different instructional concepts: a traditional instruction and the productive failure concept (Kapur, 2009). In a traditional instruction the students get the necessary knowledge to solve the upcoming tasks before they work on them. With productive failure concept the students start to work on the tasks on their own with no or less prior instruction. Normally they make mistakes and cannot solve the tasks correctly. Afterwards the failures are discussed and the teacher presents the missing information. This kind of concept is known in mathematics and seems to be suitable for promoting the understanding of conceptual knowledge and problem solving abilities (Loibl et al, 2013). We transfer this idea in physics education by using our sequence of optical blackboxes. An analysis of the different types of failures of 6th graders solving optical blackbox experiments is shown.

We will present our materials and the whole research program with optical blackbox experiments. However, the change in motivation of older students and a comparison between older and younger students will be in the focus of the presentation.

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Advancing the professional development of science teachers through engagement with research

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In this talk I will argue that teachers' professional learning can be advanced by engagement with research and research outcomes in different ways. Based on evidence from my collaboration with teachers through funded research projects, higher degree work and professional development I will discuss how different forms of engagement, as suited to individuals and circumstances, can enable teachers to be critically reflective of practice and their own learning. I will draw on examples from research and development projects on teaching argumentation to demonstrate the value of being involved or using outcomes from these projects. I will also use a few examples from reflective accounts written by my masters and doctoral students to show how their research for these degrees has advanced their professional knowledge. A key feature of my current work is on the development of action research with teachers in schools, who are investigating aspects of their own practice. I believe these kinds of inquiry can fruitfully enhance the engagement of teachers with research in the current climate, as evidenced by recent activity within the ASE Research Specialist Group.

School-based professional development for interactive teaching with technology: lessons learned from initiatives in UK and Africa

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This talk will focus on school-based teacher professional development (TPD) in the area of interactive pedagogy in technology-supported learning contexts. It is illustrated with examples based on contemporary TPD models that encourage peer learning, experiential tasks and classroom trialling, using lesson video exemplars of practice to stimulate discussion, critical reflection and lesson planning. The presentation explores how we can assist teachers in understanding and exploiting the potential of using digital technology to support subject learning, critical thinking and inquiry – especially through classroom dialogue. At Cambridge we have developed a theoretically informed workshop programme plus multimedia resource bank (http//tinyurl/OUPIWB) for sustained, school-based TPD. My team investigated its impact on the quality of classroom dialogue in contexts using digital technology – especially the ubiquitous interactive whiteboard/display screen. Outcomes of the research include multimedia professional development resources to support effective digital technology use and dialogue.

Colleagues and I have also created and trialled multimedia professional learning resources for interactive primary teaching of mathematics and science – with and without technology – in sub-Saharan Africa (www.oer4schools.org). The OER4Schools project introduced interactive teaching methods, Open Educational Resources and mobile devices into Zambian primary schools through school-based TPD. The presentation will consider what lessons can be learned from this very different context and how resources can be adapted to be culturally appropriate.

Designing and Evaluating Effective Professional Learning

Thomas Guskey

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Professional learning leaders today are expected to show that what they do makes a difference. Stakeholders at all levels want to know if investments in professional learning truly result in improvement in the practices of educators and, ultimately, in the performance of students. This presentation explores factors that contribute to the effectiveness of professional learning and outlines the various levels professional learning evaluation. The appropriate application of these levels is described, along with procedures for establishing reliable indicators of success during professional learning planning. Participants will learn how to design and implement more effective professional learning activities, how to gather quantitative and qualitative evidence on effects, and how to present that evidence in meaningful ways.

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Is there a shortage of STEM teachers in Europe?

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The 2015 report "Efforts to increase students' interest in pursuing STEM studies and careers" by Kearney, C., devoted a chapter to initiatives identified in 30 countries surveyed across Europe related to the recruitment of STEM teachers. It found that 37% of countries report that initiatives are planned or in place to address the issue of recruiting more STEM teachers in schools. Are the countries which reported national initiatives in this area, the only ones facing a shortage of STEM teachers? What are the main reasons behind this shortage? Why are other countries not facing a shortage? To attempt to answer these questions, the article reports on two recent information gathering activities which took place during February – March 2016: 1) a questionnaire to Scientix National Contact Points concerning whether there is a shortage of STEM teachers at national level; and 2) an online survey to the Scientix Teachers Panel concerning the situation of STEM teacher recruitment in their own school and local schools. The article succeeds in providing a snapshot of the current situation. While a certain number of countries clearly suffer from a shortage of STEM teachers and have reacted by implementing one or more initiatives specifically to target the issue, this is not the case for the majority of countries. The article reports that some countries do not have sufficient evidence to be able to state whether or not there is a shortage of STEM teachers as this information is not collected in any systematic way at national level. Other countries indicate they do not currently face a shortage, but that a large proportion of the current STEM teaching population will shortly retire, and therefore such a shortage is likely to appear in the coming years.

The TEMIFICATION of science teaching: Using mysteries to initiate inquiry

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TEMI, Teaching Enquiry with Mysteries Incorporated, is an EU-funded FP7 project (www.teachingmystreies.com) which ran from 2013 to 2016. The project involved 12 European partners, 9 of whom ran CPD workshops for second-level science teachers. In this paper we discuss the experiences of the Irish TEMI team, based at the University of Limerick, in running the workshops with experienced in-service science teachers (ISSTs) and pre-service science teachers (PSSTs).

TEMI is based on four innovations:

a) The use of mysteries or discrepant events to engage students in science;
b) The use of the 5E learning model to structure inquiry-based science education (IBSE);
c) The use of showmanship to sustain student engagement;
d) The use of the Gradual Release of Responsibility model to embed inquiry in a student's experience of science.

The project was built around the provision of CPD workshops for 6 cohorts of teachers; each teacher attended two one-day workshops, separated by 8-10 weeks. The first workshop introduced teachers to the TEMI idea, gave them examples of mysteries and introduced the 5E model. Teachers then worked in groups to devise a TEMI lesson to embed the idea in their practice. Between workshops teachers were asked to try out 5 TEMI ideas, chosen from a bank of resources and also to create 2 TEMI lessons of their own. The TEMI teachers, PSSTs and the UL team formed a Community of Practice using a Google+ Forum.

The feedback from TEMI teachers was very positive. The discussions at the workshops between teachers, as they shared their experience of inquiry and the TEMI approach, were the most valuable parts of the workshops. The project in Ireland has built up a substantial bank of TEMI lessons (>100), including three TEMI-focused, 8-week Transition Year Modules. TEMI Taster workshops have been run for groups of teachers at various conferences. It is intended to offer these to ISTA branches in the next school year. A special issue of Chemistry in Action! (#107) has been produced and will be sent to over 600 Irish teachers. A National TEMI Conference will be held on June 7th to bring TEMI teachers together and to introduce the TEMI idea to other science teachers and stakeholders.

We hope that the TEMI approach will become another tool in the Irish science teacher's armoury and will have continued influence on Irish science education.

How effective evaluation and a strategic approach to CPD can support school improvement: implications for teachers, schools and CPD providers

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There is a demonstrated link between teacher effectiveness and school improvement and the particular roles played by teacher education and research knowledge (Mincu, 2013)

The link between accessing subject-specific CPD and impact in the classroom is not always clear-cut: this is influenced significantly by a school's approach to subject-specific CPD and to professional development more generally. Schools differ greatly in how they manage professional learning of their staff and what support they give for sharing and embedding of good practice. There is evidence to suggest that the most strategic users of CPD are performing better and improving faster than other schools with similar patterns of CPD engagement.

In this presentation, I will draw on research evidence from the National STEM Learning Network in UK of what makes effective CPD and evaluation, and demonstrate its usefulness in supporting teachers' learning and helping them embed changes, reflect on them and sustain positive developments. I will also review what makes schools 'strategic' users of CPD, share practical advice and discuss implications for CPD users and providers.

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The effect of reform curricula on pre-service teachers' attitude towards mathematics on entry to initial teacher education

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There is a prevailing assumption in the field of education that attitudes influence behaviour. This has prompted teacher educators to focus on the role played by teacher attitudes in the teaching and learning of mathematics. This paper reports on a study which examined the mathematics attitudes of two cohorts of pre-service primary teachers entering an initial teacher education program, one decade apart. Attitudes of 360 pre-service primary teachers were compared to 419 pre-service teachers entering the same college of education a decade later. The latter experienced reform mathematics curricula at both primary and secondary levels whereas the earlier cohort experienced traditional curricula. The pre-service teachers' attitudes were determined by administering Aiken's Revised Mathematics Attitude Scale (Aiken, 1974). The scale consists of two (sub) scales measuring Enjoyment of Mathematics (E) and belief in the Value of Mathematics. Analysis of the data revealed that pre-service teachers hold predominantly positive attitudes towards mathematics on entry to initial teacher education. The earlier cohort expressed a greater enjoyment of mathematics while the later cohort exhibited higher scores on the value of mathematics scale.

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Pre-service mathematics teachers' concerns and attitudinal beliefs on implementing curriculum reform

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In 2010, a major reform of the Irish post-primary mathematics curriculum was introduced. This reform not only involved changes to the mathematical content of the syllabus, but also emphasised problem-solving approaches to teaching and learning mathematics. In tandem with the reform, in-service professional development over a number of days has been made available to all post-primary mathematics teachers with over 4,000 teachers attending such training (PMISG, 2014). However, as these specialised professional development programmes are drawing to a close, newly qualifying mathematics teachers will not have opportunity to participate such in-service initiatives. Furthermore, pre-service teachers (PSTs) who commenced study for a teaching qualification in 2015 have no experience of the new curriculum, having progressed from second level education prior to the reform. This particular cohort of PSTs, who did not experience any of the new curriculum strands as post-primary students, will begin their teaching practice with little, if any, knowledge of the content of the reform and implications for their pedagogical practices. In this research, we investigate the concerns and efficacy beliefs of this cohort of PSTs towards the curriculum reform. 42 PSTs from four institutions participated in the research. Preliminary data based on questionnaire data from Charalambos and Philippou (2010) and additional qualitative responses are presented in this paper. Findings suggest that this group of PSTs do not feel confident about their content knowledge in relation to the curriculum reform and show little understanding of the pedagogy underpinning the new curriculum.

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Students' sense of belonging to maths in the transition from post-primary to tertiary education

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In University College Dublin, the undergraduate initial teacher education programme in post-primary Science and Mathematics Education is offered via the common-entry Science Programme. This Science programme is designed to give students the opportunity to explore their interests in the first two years, and not commit to their degree pathway until the end of second year. All students interested in pursuing one of the Science and Mathematics initial teacher education programmes must take a core education module and three core mathematics modules as "tasters" in first year. Given the novel nature of this common-entry model of initial teacher education, especially in Ireland, we were interested to explore the factors that impacted students' decisions to pursue the education pathways in second year and beyond. Since these pathways require students to take mathematics to degree level, we were especially interested in how students' experiences of mathematics both at post-primary level and first year at university influence their decision to study mathematics beyond first year. An important factor in predicting students' further study of mathematics, particularly at undergraduate level, is their sense of belonging to mathematics (SBM). Good et al (2011) created and validated a "sense of belonging to math" survey instrument, and found that in a study of first year mathematics students in an elite university in the US, it predicted students' intent to continue their mathematics studies. At the end of the academic year 2014-15 a survey, based on that of Good et al (2011), was completed by 33 of the 38 first year Science students taking the core Education module. The survey measured students' SBM at the end of post-primary school and again at the end of first year. Students were also asked about their intent to study further mathematics.

A statistical cluster analysis was performed on the data collected on the SBM at post-primary school, and also on the change in SBM in the transition from school to university. Two distinct clusters emerged in both of these analyses. Our findings suggest that students with a strong SBM experienced little or no drop in SBM in the transition to university, while those with a lower SBM from school, experienced a more significant drop in the transition to university. Interviews conducted with seven students from the group of 33 shed further light on the clusters that emerged, and especially on factors that may impact SBM at post-primary school.

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Promoting and advancing the teaching of science for students with special educational needs

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The notion of "science for all" suggests that all students—irrespective of achievement and ability—should engage in opportunities to understand the practice and discourse of science (Villanueva and Hand, 2011). The experience of science will enable students with Special Educational Needs (SEN) to develop a greater understanding of the world around them as well as developing a range of transferrable skills (SESS, 2008). Research findings consistently support the central role of the teacher in the education of students with SEN and there is evidence that the quality of teachers and their teaching are the most important factors in student outcomes (NCSE, 2013). Classroom teachers require the knowledge, skills and ability to understand and provide opportunities for all students, including those with SEN, to participate in and enjoy meaningful learning experiences in science.

Effective Continuous Professional Development (CPD) for all teachers is an essential aspect of realising the notion that students with SEN can access the science curriculum, participate in inquiry based science classrooms and benefit from the knowledge gained from these experiences. The Special Education Support Service (SESS) as a support service for teachers is committed to the development of teachers' knowledge and skills with theoretical and practical perspectives, so that students with SEN can reach their full potential.

This presentation seeks to examine how we can promote and advance the teaching of science for students with SEN. The particular challenges for students with SEN in learning science along with the challenges for teachers in facilitating inclusive science classrooms will be explored. The presentation will also provide a rationale for differentiated instruction in the science classroom and give examples of innovative approaches to teaching and learning science for all students. The inclusive potential of the inquiry based classroom will be examined in the context of differentiated instruction as a means of including students with SEN who may otherwise be academically realization34. Enabling students with SEN to become active participants in the community of practice of science classrooms is the ultimate goal and the role of high quality CPD for teachers with respect to this is intrinsic to this realization.

The presentation is relevant for all school settings, primary, post-primary, special schools and special classes.

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An evaluation of a national continuous professional development programme in science education for Irish primary school teachers.

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Primary school teachers often avoid teaching science and using inquiry-based methods as they feel they have insufficient conceptual and pedagogical knowledge (Jarvis & Pell 2004, Murphy *et al.* 2007). Research indicates that the provision of appropriate Continuous Professional Development (CPD) could help remediate some of teachers' concerns (Murphy *et al. 2015*). In 2014/2015, 23 Irish Primary schools participated in a pilot National CPD programme that was developed by Science Foundation Ireland. This was a whole-school, three by two hour programme aimed at developing primary teachers' confidence and competence in utilising more child-led inquiry-based approaches to teaching science. This paper reports on an evaluation that examined the impact this programme had on these primary teachers' experiences of, attitudes towards and confidence in teaching science. Questionnaires were administered and interviews conducted prior to and at the end of the CPD programme. In addition, a follow-up survey was conducted a year after the programme to establish whether participation in the programme had any longer-term effects on participants' approaches to and attitudes towards teaching science. The findings from the evaluation revealed that a significant majority of the participants reported that participation in the CPD programme had a positive impact on their attitudes towards teaching science and that they felt more confident teaching science through inquiry. While there was a significant, positive impact on teachers' confidence in teaching all strand units of the primary science curriculum (DES, 1999) the most significant change in teachers' reported confidence was apparent in the strand units that were explicitly addressed in the workshops. The findings also revealed a significant increase in the number of teachers who reported that as a result of participating in the programme they now teach science more frequently each month and more frequently adopt more child-led, inquiry-based approaches to teaching science. Participants maintained that the three by two-hour workshop, whole-school approach that was adopted in this CPD programme was a significant factor in the programme's success.

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The RDS STEM Learning Programme: Challenging science facilitation

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The RDS STEM Learning project commenced in 2012 following the growing awareness of the importance of development of STEM skills at primary level in the 2000s. The RDS had worked with St. Patrick's College and Dublin City University under the aegis of CASTeL throughout the 2000s on the RDS Science Live for Teachers programme and this culminated in the successful SL4T International Symposia between 2007 and 2010. The success of this programme foregrounded the huge swell of interest and need to provide in-career support for serving primary teachers. The RDS, in partnership with CASTeL, sought to establish a dedicated in-career programme which focussed on providing participants with opportunities to explore, engage with and reflect on, a range of techniques and methodologies for teaching the primary science curriculum through inquiry.

The specific goals of the programme were to: i) to support and challenge primary school (principals, teachers and students) to engage with and understand science, technology, engineering and maths, and to demonstrate the relevance of STEM subjects through the development and application of knowledge and skills; ii) to introduce new and innovative techniques to support primary school teachers in the delivery of content and procedural knowledge as required by the curriculum; iii) to provide primary school teachers with a forum to learn and practice science teaching; and to provide primary school teachers with tools and supports to confidently teach hands-on science in the classroom.

In the first pilot phase (2012 – 2015) there were two sub-programmes to the overall Programme - a) RDS STEM Learning Teacher Education Programme – aimed at teachers keen to increase their confidence and progress their STEM education skills and b) the RDS STEM Learning Facilitator Programme – aimed at teachers with good knowledge of and confidence in teaching Science and Maths who want to take their learning further, becoming peer leaders in STEM education. In the case of the individual teacher, the teacher becomes the Facilitator in implementation of the RDS STEM Learning Teacher Education Programme. The overall Programme operated with a strong emphasis on hands-on enquiry-based approaches to teaching and learning science at primary school level.

This paper will present the evaluation of the pilot phase, highlighting the complexity of the development of practice, and how impacts are subtly couched within everyday teaching and difficult to isolate. We will nonetheless note the positive impact that the project has had on participants' confidence and pedagogical knowledge of teaching through inquiry, particularly with regard to their confidence in teaching science and technology in terms of 'design & make' and establishing a reflective community of practitioners among the participants.

Assessment of scientific literacy in the Scottish curriculum for excellence

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Scientific literacy can be loosely defined as a familiarity with science and the ability to engage with scientific issues (DeBoer 2000). There has been increased focus on scientific literacy in education in recent years and it is now recognised by many as essential to modern science education. According to the OECD's Programme for International Student Assessment (PISA), scientific literacy can be categorised into three competencies: Explain phenomena scientifically; evaluate and design scientific enquiry; and interpret data and evidence scientifically, with each competency consisting of five sub-competencies (see OECD 2013).

The Scottish Curriculum for Excellence contains innovative assessment elements such as the National 5 course's "Assignment". This assessment asks students to research a topic of choice and present their research. It is completed within school, overseen by teachers, but is assessed externally by the SQA. This novel assessment aims to assess many competencies (and sub-competencies) associated with scientific literacy, as laid out by PISA, such as analysing and interpreting data, drawing conclusions, and evaluating scientific arguments and evidence from different sources (OECD 2013, SQA 2014).

In this study, the implementation of the Assignment will be evaluated by comparing the stated aims of the Assignment to the experiences of teachers and students, using teacher and student questionnaires. Six biology teachers completed questionnaires reflecting on their experience of teaching the National 5 Assignment with their classes and approximately 150 students completed a similar questionnaire reflecting on their experience of carrying out the Assignment. Teachers were also interviewed about their experience of carrying out the Assignment. Through examination of these, the research aims to reveal which competencies of scientific literacy are being assessed in practice compared to those aimed by the SQA.

The presentation will focus on the teachers' motivation for and their experience of taking part in this research, as well as giving a brief overview of the research and findings so far.

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To develop, implement and evaluate a transition year module based on the principles of the Teaching Enquiry with Mysteries Incorporated project

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This study aims to develop teaching and learning resources for Transition Year Science in accordance with the Teaching Enquiry with Mysteries Incorporated (TEMI) guidelines. Transition Year is a unique year in the Irish Education system, and in recent years it has become a well-established area of Irish schools. Transition Year is a syllabus free year that aims to incorporates the numerous subject choices available to students. The TEMI project is part of a response from the European Commission to tackle "the alarming decline in young people's interest for key science studies and mathematics" (European Commission 2007). The overall aim of the TEMI project is to "transform science and mathematics teaching by offering support to teachers to introduce enquiry-based teaching into a classroom" (TEMI, 2013). TY Science offers teacher the opportunity to trial new techniques, look at different areas of science and promote the uptake of all science subjects. This project uses this opportunity to integrate a TY module based on the TEMI approach into the classroom. The TEMI project is an FP7 EU funded project and has 13 partners across Europe. It is targeting schools in each of these partner areas to develop and implement innovative training programs. TEMI's aim is to spread IBSE, and what makes TEMI unique is how it has conceptualised IBSE in terms of 4 innovations; Showmanship, Gradual Release of Responsibility, Mysteries (Discrepant Events) and the 5E cycle (TEMI, 2013). This project focuses on the 5E cycle and Mysteries. Bybee's 5 5E model (Bybee et al., 2006) of Inquiry which includes: Engage, Explore, Explain, Elaborate and Evaluate. The main emphasis is placed on the 'Engagement' stage to incorporate discrepant events or mysteries. Discrepant events and mysteries can be described as "a phenomenon that occurs in a way that seems to run contrary to initial reasoning" (Wright and Govindarajan, 1995, p. 205). The overall goal is to provide teachers with new resources and methods to teach STEM subjects (Science, Technology, Engineering and Mathematics) using mysteries and discrepant events as a starting point (Childs 2013). The Transition year module in this study was created as an opportunity for students to learn about the world outside academia and in a way that was relatable to student's lives at home. This particular TY module was called 'Homemade Heroes' and contained mysteries that could be carried out using mainly household materials and equipment. The module contained 8 units to be carried out over an 8 week period, each week integrated different elements of Biology, Chemistry and Physics. The Transition Year Module was trialled in 7 Irish post-primary school during Pre Service Science Teachers' (PSSTs') 4th Year School Placement. The participating schools were a mixture of all-girls/boys and co-educational. Participating teachers, were required to keep a diary of the lessons they trialled along with completing a teacher questionnaire at the end of the implementation. Students who participated in the TEMI lessons were required to complete pre/post-module questionnaires. Both questionnaires contained quantitative and qualitative research methods to ensure the most effective data collected. The collected data was analysed using the IBM SPSS Statistics (Version 22) software.

The key findings of the research highlighted the motivational aspects of discrepant events incorporated into an IBSE approach. Learner motivation was increased in the immediate and short term, although the long term effects were not investigated.

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Step into science project: Engaging students, teachers and parents in debates

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This project aims to facilitate the teaching and learning of Irish lower second-level curricular objectives on Nature of Science, through engaging teachers, students and guardians in school debate events on socio-scientific issues. The project is funded by Science Foundation Ireland, and is led by EPI-STEM, The National Centre for STEM Education at University of Limerick with the partnership of the JCT. The Junior Cycle science curriculum promotes skills such as communication and argumentation required for engaging in debates. Yet the kinds of pedagogical strategies demanded by debates are not typically part of teaching practice (Osborne et al. 2004). The first stage of this project therefore is CPD supporting science teachers to implement argumentation into their teaching of science in order to provide students with a foundation for the kinds of skills they need to draw on when debating scientific issues. Argumentation has been a significant area of research in recent years (Erduran, Ozdem & Park, 2015) and has been advocated in science teacher education (Erduran, 2006). The CPD workshops were developed in partnership with the JCT and implemented by them in May 2016. The teachers involved will subsequently implement argumentation activities into their teaching and coordinate a debate event in Autumn 2016. Involving the community in school science is a critical element of this project. Hence students will prepare for their debate event with the support and involvement of a family member in targeted homework activities, provided to teachers during the CPD workshop.

This research takes a case study approach, collecting data from multiple participants to explore the impact of the programme (Leedy and Ormrod 2001). Evaluation instruments will be used to assess (i) teachers' perspectives on the CPD and (ii) teachers', students' and guardians' perspectives on participation in debates. This paper will outline the overall design of the project, along with the detail of the design of the teacher CPD workshop. It will also report on initial findings from the teacher participants' post-workshop evaluation of the CPD element of the programme.

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Myths and misconceptions among students and teachers about the nature of science

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In recent years, 'nature of science' (NOS) has been advocated as a critical outcome in many different national science education reform initiatives around the world (e.g. Australia, New Zealand, South Africa, the U.K. and the U.S.) (Lederman, 2007). Understanding NOS is crucially important as it facilitates the learning of the subject matter in science, but there are many other reasons why a good grasp of NOS is so important for our students. School leavers need to be able to make informed decisions on socio-scientific issues, make sense of the technology in everyday life, appreciate the value of science as part of our culture, and be equipped to grasp the ethical issues that arise from modern scientific progress (Driver. Leach, Millar, and Scott, 1996).

There are many long-standing and pervasive myths and misunderstandings about NOS among students and science teachers (McComas, 1996). Some of the more common misconceptions include: the existence of a universal 'scientific method'; proper science must involve experiments; a hypothesis is an educated guess; observations and inferences are similar in nature; a theory is an unproven explanation; a theory becomes a law when there is enough proof, or when enough time has passed during which the theory has not been disproved.
There are other misconceptions regarding scientists themselves that should be addressed. Science is widely perceived to be a pursuit carried out by dispassionate people (usually men) who spend long hours working alone in their labs, carrying out routine tests in a 'by-the(recipe)-book' fashion. Scientists are not seen as social, creative, or imaginative, but instead are cut-off from 'the real world'.

Compounding the confusion regarding NOS is the prevalence of what Ben Goldacre (2009) refers to as "Bad Science". Students need guidance in order to better distinguish authentic science from pseudoscience.

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TEACHING AND ASSESSING SOCIO-SCIENTIFIC RESEARCH IN PRE-SERVICE TEACHER EDUCATION

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Development of scientific literacy is an important feature of the new Junior Cycle Science Specification, which will be implemented in September 2016. Scientific literacy is described as the "ability to engage with science-related issues, and with the ideas of science, as a reflective citizen" (OECD 2013 p7). The scientifically literate individual can explain phenomena scientifically, evaluate and design scientific enquiry, and interpret data and evidence scientifically (OECD 2013).

Student-led socio-scientific research has been used to develop and assess many skills associated with scientific literacy. The new Irish Junior Cycle science specification includes a Science in Society Investigation (SSI) which aims to assess students' ability to research a socio-scientific issue, analyse information and secondary data, evaluate claims and opinions and draw evidence-based conclusions (NCCA 2016 p10). The SSI will be carried out by students with the support and guidance of the teacher and student performance will be assessed by the teacher (NCCA 2016 p10). The SSI will be carried out in Irish schools from December 2018 and therefore newly qualified teachers will need to be prepared to facilitate and assess the student learning.

This study will discuss the design and implementation of a series of lessons with pre-service teachers (PSTs) that involve carrying out their own SSI, based on the Junior Cycle Science SSI. This study has been conducted over two years with two cohorts of PSTs, a total of 50 students, completing a concurrent undergraduate teacher education programme. Thematic analysis has been used to analyse data collected from PSTs on their experience of and the competencies developed in the SSI. The competencies that the SSI has developed and assessed will be discussed in the context of the PISA framework for scientific literacy. The findings of this study will inform future classroom practices in the facilitation and assessment of socio-scientific research.

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PCP as a bridge between Theory and Practice in Chemistry Education

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Gilbert (2005) highlights that models of psychology and their implications, such as that of George Kelly (1955), should be considered regarding science education. Kelly refers to the assumption of 'opposites' such as that of positive *versus* negative regarding the atom. Fransella (2003) asserts that chemistry may be viewed as sharing with PCP the inherent assumption that people think in terms of contrast. An alignment also exists between 'chemistry education' and PCP. Clement (2008) notes that efficient mental models usually embrace the inter-relationships within a system *versus* a collection of isolated facts. Despite Nersessian (2008) noting that our human cognitive apparatus is capable of mental modelling and abstraction, Cracolice et al., (2008) state that a very low percentage of students in secondary school possess sufficient reasoning skills. Hence, the *Information Processing Model* of learning is important. Potentially, a related cycle to consider what constitutes learning is Kelly's *Experience Cycle.* Pope and DeNicolo (2016) emphasise the importance of teachers questioning their teaching to improve the understanding of their students. Earlier, Pope and DeNicolo (2001) acknowledged the vital role of '*permeable*' constructs in the elaboration of understanding.

In this paper a set of such constructs are offered within the context of the *Experience Cycle.* It is hoped they might be used as axes to assess learners' progress and to gauge potential appropriate teaching responses to the learning status of concepts in the classroom. Within this approach, the dichotomous nature of constructs is employed to *measure* key ideas such as utilising students' views as starting points and resources. It may also assist in the metering of student implicit knowledge elements. This is aligned with the view held by Talanquer (2014) that what appears as random guessing in student answers, may be the natural outcome of intuitive reasoning. Hence, it is hoped that PCP will provide a framework that allows teachers to improve the reasoning skills of their students and thereby serve as a bridge builder between theory and practice.

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Interdisciplinary science teacher education in Denmark

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Traditionally science teacher education for lower secondary schools in Denmark has been conducted as a 4 year study at University colleges. These educations have been structured in a way that you as a teacher can be specialized in 3 domains of teaching. In the light of the new educational focus on 21st Century Skills (Pellegrino & Hilton, 2013) it becomes clear that many competencies are generic and therefore could be developed in more than one domain. Content specific arguments towards interdisciplinary science education can also be found in Lattuca, Fath, and Voigt (2004). It is in the light of such arguments that we have established a new combined science teacher education which is now running with the first cohort.

The science teacher education is not only new in that it combines general science educational and pedagogical issues across several science domains. It is also new in that the education involves collaboration between university colleges and a university. The new structure involves that science teachers following this educational program has 1 semester placed at the university where they do content specific courses and science educational courses together with other university students.

By combining the educational approach in general science education it becomes possible for the teachers following the program to end up with specialization in 4 domains instead of the traditionally 3 domains. This again is an advantage in conduction interdisciplinary science teaching.

This presentation will highlight the educational considerations behind this new approach to science teacher education as well as first impressions from students at cohort one.

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Role of technology in promoting formative assessment practices in science and mathematics classes

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This paper will report on a professional development (PD) course designed and implemented by researchers in Maynooth University Ireland as part of the FaSMEd1 project (formative assessment in science and mathematics education). This project researched the use of technology in formative assessment (FA) classroom practices. Recent changes to the lower secondary education in Ireland have highlighted the central role of FA and technology in developing student's key skills and capacity for lifelong learning.

Timperley and colleagues highlight the importance of creating dissonance or cognitive conflict in teachers' thinking in order to bring about changes in their practice. They need to confront what they are doing at present and see better alternatives, rather than layering new thinking onto old practice (Timperley et al., 2007). This is especially important in the development of FA, as many pedagogical practices used may appear familiar to teachers. Teachers participated in four professional development sessions with the researchers throughout the 2014/2015 academic year that challenged their practices and beliefs about their assessment practices. Between sessions teachers shared their reflections and student work on an online learning platform. These sessions were followed up by school visits and classroom observations, teacher and student interviews and conversations following classroom observations.

The research work within the project leads to the elaboration of a three-dimensional model taking into account the FA strategies, the properties of technologies and the role of actors. This model has been used for lesson analysis and completes the variety of viewpoints coming from qualitative interviews analysed using MAXQDA software. Q-Sort data analysed using PQMethod software, video data using a whole-to-part inductive approach and the questionnaire data analysed using SPSS. Findings suggest that many of the teachers began to create new, collaborative learning environments where students became active participants in their learning. Findings also report on the affordance and constraints of the contexts in which the teachers were working that affected their PD. The success of the FA strategies was largely dependent on the skills of the teacher in anticipating misconceptions, selecting appropriate topics for discussion and generating purposeful discussion through effective questioning.

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Evaluation of the Impact of SAILS IBSE and Assessment Teacher Education Programme

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Inquiry based science education is recognised and documented as a suitable method for learning science in various reports, and it now has a place in many national curricula (NCCA, 2015; Ontario Ministry of Education, 2008). However, even though inquiry has been promoted over many years (NRC, 2000; Minner et al., 2010), numerous teachers struggle with this methodology due to their lack of understanding of inquiry, how to implement it effectively in the classroom, time required and perceived classroom management issues (Hong & Vargas, 2016; Laius, et al., 2009; Jackson & Boboc, 2008). The SAILS project was created to support teachers across Europe in adopting an inquiry approach in their classrooms and also focused on the assessment of the skills that are developed during inquiry teaching. 12 partners from across Europe ran teacher education programmes for their participating teachers. To determine the inquiry and inquiry assessment practices of teachers across Europe and the impact of this programme on its participants, evaluation tools were developed which were completed before and after the teacher education programmes.

In total, 305 in-service teachers completed both the pre- and post- evaluation tools. This matched sample was used to determine the initial inquiry and inquiry assessment practices of the participants, the effect of the programme on these practices, and the main constraints faced by the teachers in IBSE assessment in different countries.

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Preparing the ground: considerations on cultivating scientific inquiry through curriculum

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Science education in secondary schools may be considered to have several purposes to include increasing the number of STEM undergraduate enrolments (economic), developing a scientifically literate citizenry (social) and appreciating the epistemology of the domain (intellectual culture).

Inquiry Based Science Education (IBSE) aims to provide students with learning experiences authentic to scientific work and thinking, ideally drawing on student natural curiosity to address contemporary contexts in a flexible, problem-based approach. Science Technology and Society (STS) advocates an interdisciplinary approach integrating multiple disciplines with science, implied from real world problems, to improve student motivation towards science.

These inductive, student-centred approaches are largely at odds with teacher-centred, didactic approaches that remove students from decision-making. Research has shown that Initial Teacher Education (ITE) and Continuing Professional Development (CPD) have limited effects on changing practice.

This paper proposes that the fundamental change in mind-set required to realise IBSE must focus on increasing student engagement, not solely motivation with science, and considers the role of teacher agency with respect to the new junior science specification in the Junior Cycle Framework (JCF). Empirical work on how power dynamics in classrooms effects IBSE will lead to evidence of the impact of a curriculum structure (Negotiated Integrated Curriculum) on student agentic engagement in STS themes. Considerations will be offered regarding the cultivation of an inquiry habitus in the context of the JCF, ITE and CPD.