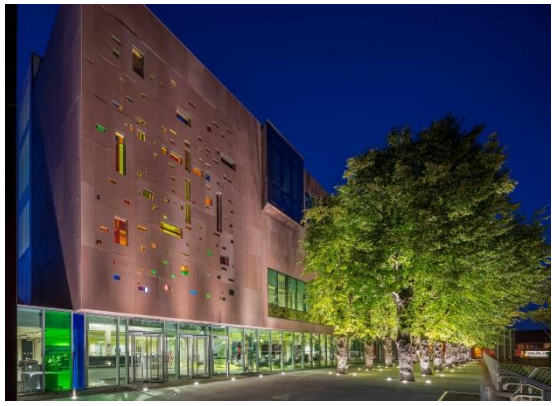
SMEC 2018

Connecting Research, Policy and Practice in STEM Education

Book of Abstracts

The 8th Science and Mathematics Education Conference (SMEC), hosted by the Centre for the Advancement of STEM Teaching and Learning (CASTeL)

DCU Institute of Education,
26th June 2018.



Ollscoil Chathair Bhaile Átha Cliath
Dublin City University

Introduction

We, the organising committee of SMEC 2018 would like to welcome you to Dublin City University for this conference entitled *'Connecting Research, Policy and Practice in STEM Education'.*

SMEC 2018 is the eighth in a series of biennial 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 a 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 the following themes: Teacher Education; Inquiry-based learning; Assessment; Facilitating authentic learning; Sciences serving science; and Exploring the interconnections between STEM subjects. The recent STEM education policy statement 2017 - 2026 (Government of Ireland, 2017) recommends the enhancing and embedding of existing good practice in STEM Education and calls for attention to establishing what is necessary to provide a quality STEM education experience. In this context, the theme for this year's conference is *Connecting Research, Policy and Practice in STEM Education.*

Organising Committee

Dr. Siún Nic Mhuirí (Chairperson)

Dr. Paul Grimes (Chair Early-Researchers' day)

Dr. Lorraine Harbison

Dr. Eabhnat Ni Fhloinn

Dr. Cliona Murphy

Dr. Aisling Twohill

Scientific Committee

Dr. Sinead Breen

Dr. Lorraine Harbison

Dr. Orla Kelly

Dr. Brien Nolen

Miriam Ryan

Dr. Aisling Twohill

Dr. Paul Van Kampen

Table of Contents

Time/Location of presentation	Title and Authors	Page
	Programme	***1***
	Keynote Speakers	
9:15	**Research that makes a difference: Why impact matters**	***2***
G114	Professor Merrilyn Goos, Director of EPI*STEM, University of Limerick	
2:00	**Quality Enhancement in Mathematics Education: Some Insights into German**	***4***
G114	**Initiatives and Research**	
	Professor Anna Steinweg, University of Bamberg.	
4:30	**STEM - The whole is greater than the sum of its parts**	***6***
G114	Professor Deirdre Butler, Centre for the Advancement of STEM Teaching and Learning, CASTeL, Dublin City University.	
10.55 – 11.55 E401	**Lesson Study**	
	A Theory-Driven Evaluation of Lesson Study as a Model of Professional Development to Support the Enactment of the New Primary Mathematics Curriculum	***7***
	Tracy Curran	
	The Generation of 'Powerful Mathematical Thinking' through Lesson Study	***8***
	Thérèse Dooley	
	Innovative Approaches to STEM Initial Teacher Education: The Case of Lesson Study	***9***
	Mairéad Hourigan, Aisling M. Leavy	
	Developing Pedagogical Content Knowledge in Initial Teacher Education: Peer Assisted Tutoring and Lesson Study	***10***
	Aoibhinn Ní Shúilleabháin, Maria Meehan	
10.55 – 11.55 E403	**Policy, Systems, Standards**	
	European STEM Schools Report: Key Elements and Criteria	***11***
	Noelle Billon, Agueda Gras-Velazquez	
	The Future 'Vision' for Science Education: A Critical Analysis of the STEM Education Policy in an Irish Context	***12***
	Nicola Broderick	
	Accrediting Pre-Service Teachers' Innovative Practice in Primary Science within an ITE programme; Why and How?	***13***
	John McCullagh, Andrea Doherty	
	How Numerate are Pre-Service Teachers?	***14***
	Kathy O' Sullivan, Dr. Niamh O' Meara, Merrilyn Goos, Paul F. Conway	
10.55 – 11.55 E405	**Improving STEM Teaching A**	
	A Temporal Profile of Students' Attitudes to Learning from a Secondary School Science Classroom	***15***
	Robert Clarke	
	Improving problem-solving abilities of high achieving transition year students	***16***
	Aidan Fitzsimons, Eabhnat NÍ Fhloinn	
	Bringing Computational Thinking into STEM Education in Primary School	***17***
	Margaret Leahy, Deirdre Butler, Deirdre Mc Quaid, Róisín Ryan, Francis Tormey	
	Computational Thinking via App Inventor – Lessons from the Irish Context	***18***
	Monica Ward, Gary Conway, Julie Powers, Julie Regan	
10.55 – 11.55 Lego Innovation Studio	**Workshop**	
	Investigating Students' Learning of Differential Equations in Physics	***19***
	Diarmaid Hyland, Paul van Kampen, Brien Nolan	

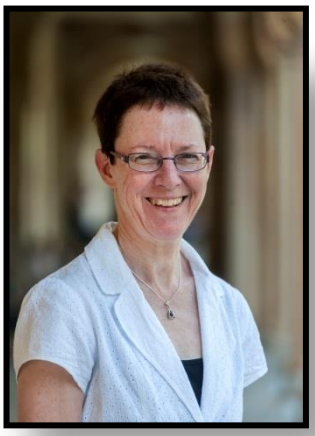
12.00 – 1.15	**Beyond STEM: STEAM Education, Open Schools and More**	
E401	**Developing Open Schooling in Ireland: Examining Schools as Evolving Learning Ecosystems** Paul Grimes, James Lovatt, Eilish McLoughlin, Caitríona Mordan, Padraig Murphy	***20***
	Connecting Voices Across Disciplines – STE(A)M in Junior Cycle Aine Woods, David King	***21***
	STEAM Education Outside the Classroom – a CPD model Orla Kelly, Tomas Aylward, Yesim Tunali Flynn, Janet McKennedy	***22***
	WiSTEM2D: Connecting Women in Science, Technology, Engineering, Math, Manufacturing and Design Regina Kelly, Oliver McGarr, Merrilyn Goos	***23***
	Education for Sustainable Development through Inquiry-Based Science: Exploring a Programme of Professional Development for Irish Primary Teachers Cliona Murphy, Greg Smith, Benjamin Mallon	***24***
12.00 – 1.00	**Working With STEM Teachers A**	
E403	**Action Research Facilitating Belief Change for Out-of-Field Mathematics Teachers** Ciara Lane, Máire Ní Ríordáin	***25***
	The Evaluation and Design of Tasks by Science and Mathematics Pre-Service Teachers Majella Dempsey, Ann O'Shea	***26***
	PRiME: A Project to Promote Subject Leadership in Primary Mathematics Among Student Teachers Maurice OReilly, Thérèse Dooley, Paul Grimes, Lorraine Harbison, Aisling Twohill	***27***
	The RDS STEM Learning Programme: Challenging Science Facilitation Karen Sheeran, Sandra Austin, Odilla Finlayson, Maeve Liston, Tom McCloughlin, Cliona Murphy, Greg Smith	***28***
12.00 – 1.00	**Improving STEM Teaching B**	
E405	**A Q Methodology Approach to Exploring Second Level Students' Perceptions of Science Teaching, Learning, and Assessment** Niamh Burke	***29***
	Conceptual Change in Upper Second Level Electrostatics – The Use of Structured Inquiry Richard Moynihan, Paul van Kampen, Odilla Finlayson3, Eilish McLoughlin	***30***
	In Support of Open Learning Outcomes in Leaving Certificate Chemistry: The Curious Case of The 'Cross' Experiment John O'Reilly	***31***
	Augmented Reality and Mathematics – a Taster App Monica Ward, Odhran Daly, Joseph Travers	***32***
12.00 – 1.00	**Workshop**	
Lego Innovation Studio	**Blurring the Boundaries Between Informal and Formal Science in the Classroom** Claudia Fracchiolla, Shane Bergin	***33***
3.10 – 4.10	**Investigating STEM Teaching**	
E401	**A Cognitional Theory for Mathematics Methodology on an Initial Teacher Education Programme** Cornelia Connolly, Tom Cosgrove, Tony Hall	***34***
	Teacher and Student Experience of Inquiry in the Context of SSI: A Comparison of Two Approaches Ruth Chadwick, Eilish McLoughlin, Odilla E. Finlayson	***35***
	Teacher as Resource? How Might the Role of the Teacher in Fostering Powerful Mathematical and Language Practices be Analysed? Miriam Ryan	***36***

	Policy and Practice in the use of Multiple Connected Representations Niamh O'Meara , Patrick Johnson , Aisling Leavy	***37***
3.10 – 4.10	**Working With STEM Teachers B**	
E403	**Nature of Science in Initial Teacher Education - Illustrated Case Studies** Alison Cullinane, Sibel Erduran, Paul Conway	***38***
	STEM Discovery Week 2018 Adrienn Pap, Róbert Baldursson, Evita Tasiopoulou, Noelle Billon, Agueda Gras-Velazquez	***39***
	Supporting and Enhancing the STEM and Arts Capacity of Primary Teachers and Schools Colette Murphy, Alice D'Arcy, John O'Halloran, Fiona Naughton	***40***
	DiagnoseDys – a Dyscalcula diagnosis App Monica Ward, Méabh Horan, Joseph Travers	***41***
3.10 – 4.10	**Improving STEM Teaching C**	
E405	**Using the Knowledge Quartet to Analyse University Mathematics Teaching** Sinéad Breen, Maria Meehan, Ann O'Shea, Tim Rowland	***42***
	Undergraduate Mathematics: Engagement in Live Lectures versus Flexibility of Online Videos Emma Howard, Maria Meehan, Andrew Parnell	***43***
	The Development of a Framework to Assess Technology Enhanced Resources for Mathematics Education Caitríona Ní Shé, Ciarán Mac an Bhaird, Eabhnat Ní Fhloinn, Ann O'Shea	***44***
	The Rule of 3; A Scaffold for Teaching Chemical Maths Natalie O'Neil	***45***

Programme SMEC 2018 Tuesday 26th June 2018
DCU Institute of Education, St. Patrick's Campus.

8.30	Registration Opens			
9.15 – 10.30	**Keynote 1: Research that makes a difference: Why impact matters** Professor Merrilyn Goos, Director of EPI*STEM, University of Limerick *Heaney Lecture Theatre (G114)*			
10.30 – 10.50	Coffee and posters *Library reception area outside Heaney Theatre*			
Parallel Sessions and Workshops 10.55 – 1.00				
10.55 – 11.55	Parallel Session 1 *Lesson Study* *E401*	Parallel Session 2 *Policy, systems, standards* E403	Parallel Session 3 *Improving STEM Teaching A* *E405*	Workshop 1 *Lego Innovation Studio* F125
12.00 – 1.00	Parallel Session 4 *Beyond STEM: STEAM education, Open schools and more* *E401*	Parallel Session 5 *Working With STEM Teachers A* E403	Parallel Session 6 *Improving STEM Teaching B* *E405*	Workshop 2 *Lego Innovation Studio* F125
1.00 - 2.00	**Lunch- Canteen**			
2.00 - 3.05	**Keynote 2: Quality Enhancement in Mathematics Education: Some Insights into German Initiatives and Research** Professor Anna Steinweg, University of Bamberg. *Heaney Lecture Theatre (G114)*			
Parallel Sessions and Workshops 3.10 – 4.10				
3.10 - 4.10	Parallel Session 7 *Investigating STEM Teaching* *E401*	Parallel Session 8 *Working With STEM Teachers B* *E403*	Parallel Session 9 *Improving STEM Teaching C* *E405*	
4.10 - 4.30	**Coffee and poster session**			
4.30- 5.45	**Keynote 3: STEM - The whole is greater than the sum of its parts** Professor Deirdre Butler, Centre for the Advancement of STEM Teaching and Learning, CASTeL, Dublin City University. *Heaney Lecture Theatre (G114)*			

Keynote Speaker 1: 09:15, Heaney Theatre, G114



Professor Merrilyn Goos

Director of EPI*STEM, University of Limerick

Merrilyn Goos is Professor of STEM Education at the University of Limerick, and Director of EPI*STEM – the national Centre for STEM Education. Previously she was Professor and Head of the School of Education at The University of Queensland. She has also worked as Professor of Mathematics Education at Loughborough University, UK. She is an internationally recognised mathematics educator whose research is well known for its strong focus on classroom practice. Her research interests include students' mathematical thinking, the impact of digital technologies on mathematics learning and teaching, numeracy across the curriculum, and the professional learning of mathematics teachers. She is currently Vice-President of the International Commission on Mathematical Instruction and Editor-in-Chief of Educational Studies in Mathematics, one of the leading research journals in mathematics education. She has also gained national recognition as a mathematics teacher educator, having won an Australian Award for University Teaching in 2004 as the most outstanding teacher in the social sciences disciplines. She is the lead author of two teacher education textbooks on Teaching Secondary School Mathematics and Numeracy Across the Curriculum – the latter of which is due to be published later in 2018.

Merrilyn's keynote address is entitled:

Research that makes a difference: Why impact matters

Research that makes a difference: Why impact matters

Merrilyn Goos

University of Limerick

While measures of research quality are widely accepted in the education research community, there may be less agreement on what constitutes evidence of impact and on where to look for this evidence. This presentation considers the most common rationale for demonstrating impact, compares definitions of research impact in use in Ireland and Australia, and illustrates what engagement and impact can look like in two case studies of STEM education research conducted in Australia. The first case study is a well-established research program for embedding numeracy across the whole school curriculum. The linear logic models promoted by research funding bodies cannot capture the complexity of this type of education research, and so alternative representations are used to map the growing networks of engagement and impact over an 18 year period. The second case study is a large scale, 6 month project commissioned by the Australian government to identify characteristics of best practice in mathematics education based on student performance on national standardized tests. Despite its inherent design flaws, this project yielded insights into the potential for this type of research to generate productive engagement with policy makers. Nevertheless, questions remain as to how the findings could be used to improve teaching practice and student learning. These case studies suggest that retrospective analysis of our own research can point to "where to look" for evidence of past impact, and help us anticipate the impact of future projects.

Keynote Speaker 2: 2:00, Heaney Theatre, G114

Professor Anna Steinweg,

University of Bamberg

Anna Steinweg is Professor of Mathematics and Computer Science Education in the University of Bamberg, Germany. She is the Vice-Dean of the Faculty of Human Sciences and Education and holds the position of Head of the Bamberg Centre of Teacher Education. She is an internationally recognised expert in mathematics education, and researches in the areas of early mathematics and early algebra in particular. She is currently the editor of 'Mathematikdidaktik Grundschule - Proceedings of Conferences of the Research Group on Primary Mathematics Education' and is a reviewer for Educational Studies in Mathematics. In her keynote, she will provide a context for her own research by discussing design research and the German approach to STEM education (MINT initiatives) more generally.

Anna's keynote address is entitled:

Quality Enhancement in Mathematics Education: Some Insights into German Initiatives and Research

Quality Enhancement in Mathematics Education: Some Insights into German Initiatives and Research

Anna Susanne Steinweg, University of Bamberg
anna.steinweg@uni-bamberg.de

Research in Mathematics Education always aims for improvement of mathematics lessons in order to enhance children's development in mathematical thinking. Different approaches to achieve this objective can be observed in national and international research. In the talk my own idea of reasonable research is offered to reflect upon. Of course my research is influenced by the national circumstances in Germany.

The two-part talk first addresses the German education system and initiatives introduced by policy makers. Some information on the impact and evaluation results are presented. In the second part insight into my own research is given. Exemplarily current projects in the field of early mathematics education (Birklein & Steinweg, 2018) and algebraic thinking (Steinweg, Akinwunmi & Lenz, 2018; Steinweg, 2017) are briefly described.

All my projects have in common that the starting point is identifying key ideas. They serve as designing principles for adequate material, tasks, and learning environments. Implementing the designed tasks in schools allow teachers to become aware of key ideas -the main topics of a content area- and therefore guide classroom interaction. Moreover, exploring and regarding children's competencies in the certain content area is an important element. Only in relation to these abilities the evaluation of the designed material and learning environments can be refined and improved.

Keywords: design research, key ideas, German maths education initiatives, early mathematics, algebraic thinking

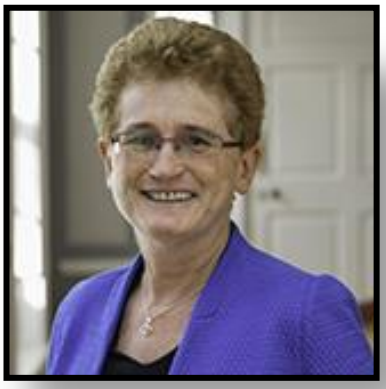
References

Birklein, L., & Steinweg, A.S. (2018). Early maths via app use – some insights in the EfEKt project. In Ch. Benz, Ch., A.S. Steinweg, H. Gasteiger, P. Schöner, H. Vollmuth, & J. Zöllner (Eds.),*Mathematics Education in the Early Years - Results from the POEM3 Conference, 2016* (pp. 231-251). Cham, CH: Springer International Publishing.

Steinweg, A., Akinwunmi, K., & Lenz, D. (2018). Making Implicit Algebraic Thinking Explicit: Exploiting National Characteristics of German Approaches. In C. Kieran (Ed.), *Teaching and Learning Algebraic Thinking with 5- to 12-Year Olds: The Global Evolution of an Emerging Field of Research and Practice* (pp. 283-307). Cham, CH: Springer International Publishing.

Steinweg, A. S. (2017). Key ideas as guiding principles to support algebraic thinking in German primary schools. In T. Dooley & G. Gueudet (Eds.), *Proceedings of the Tenth Congress of the European Society for Research in Mathematics Education (CERME10, February 1 – 5, 2017)* (pp. 512-519). Dublin, Ireland: DCU Institute of Education and ERME.

Keynote Speaker 3: 4:30, Heaney Theatre



Professor Deirdre Butler

Centre for the Advancement of STEM Teaching and Learning (CASTeL)

Dublin City University

Deirdre Butler is Professor of Education in Dublin City University (DCU) Institute of Education. Deirdre has extensive experience in developing sustainable, scalable models of teacher professional learning, and has managed projects and school based initiatives which focus on creative uses of digital technologies. She is internationally recognised as a leading scholar and expert in learner-centered pedagogical approaches. She has advised both Finish and Danish policy makers on the on the redesign of learning environments. Establishing strategic partnerships has been a key feature of Deirdre's work and a number of impactful initiatives have resulted from her collaborations with Microsoft, Business Model Adventures, the National Institute of Digital Learning (NIDL) and H2 Learning. Deirdre was also instrumental in the establishment of the flagship Lego Education Innovation Studio in the DCU Institute of Education. Recently, she won the DCU President's Award for Engagement –Special Award in Enterprise Engagement.

Deirdre's keynote address is entitled:

STEM - The whole is greater than the sum of its parts

A theory-driven evaluation of Lesson Study as a model of professional development to support the enactment of the new primary mathematics curriculum

Curran, Tracy

PhD Candidate, University of Lincoln, UK

In 2019, a new primary mathematics curriculum will be published in Ireland. In 2021, it is expected that this curriculum will be implemented in Irish primary schools. To support teachers to adopt the changes proposed in the new curriculum, in-service and professional development will be provided. In Ireland and internationally, Lesson Study has been afforded much credibility as a model of professional development to support the enactment of curriculum reform (Lewis and Takahashi, 2013; Fan Yang, 2013; Ní Shuilleabháin & Seery, 2017). Notwithstanding, as yet, there has been no research conducted on Lesson Study and curriculum reform in Irish primary schools. This research intends to investigate and evaluate Lesson Study within the specific context of supporting Irish primary teachers to enact the new primary mathematics curriculum. Given the novelty of Lesson Study as a model of professional development in Irish primary schools, and the complexity of teacher professional learning and introduction of new curriculum, the research design for this study will adopt a theory-driven approach to evaluation (TDE). TDE opens the 'black-box' of evaluation (Stame, 2004) to determine not only whether an intervention works, but also how and why it does so (Chen, 2015). Guskey's (2000) five critical levels of professional development evaluation will be employed as a framework for generating evidence of the impact and effectiveness of Lesson Study on teachers' professional learning and practice; and on children's learning with the new curriculum. Contextual and causal factors will also be investigated to identify the underlying mechanisms of Lesson Study.

Keywords:, Primary mathematics curriculum, Lesson Study, theory-driven evaluation, Guskeys (2000) five critical levels of professional development evaluation

The generation of 'powerful mathematical thinking' through Lesson Study

Thérèse Dooley and Maurice OReilly

School of STEM Education, Innovation and Global Studies, Dublin City University

In this paper a mathematics lesson on graphical representation that was taught in a Fourth Class (pupils aged 9-10 years) is analysed from the perspective of the Teaching for Robust Understanding (TRU) framework (Schoenfeld, 2014). The lesson was developed as part of a Lesson Study (LS) cycle that was conducted with teachers pursuing a Masters degree in mathematics education. LS originated in Japan but is rapidly gaining a foothold in many countries as a powerful form of pre-service and in-service professional development (e.g., Lewis, 2009). Recently some attention has been given to ways in which LS and the TRU framework might be interwoven (e.g., Dosalmas & Schoenfeld, 2018). At the core of the TRU framework are five dimensions of classroom activity – content; cognitive demand; equitable access to content; agency authority and identity; and formative assessment. Schoenfeld (2014) maintains that a focus on these five dimensions in a mathematics classroom underpins powerful mathematical thinking in learners. We discuss how the TRU framework supported our discussions as 'knowledgeable others' with the teachers at the planning and post-lesson phases of the above-mentioned LS cycle. We draw on lesson excerpts to show the deep thinking about graphical representation that was generated among the pupils, particularly, in this instance, as a result of the cognitive demand of the activities in which they engaged.

Keywords: Lesson Study, Teaching for Robust Understanding, Graphical representation, Primary mathematics

Innovative Approaches to STEM Initial Teacher Education: The Case of Lesson Study

Mairéad Hourigan, Aisling M. Leavy

Department of STEM Education, Mary Immaculate College, Limerick

There is much research examining the contribution of Lesson Study as a productive form of professional development for practicing teachers. In comparison, the potential contribution of Lesson Study within initial teacher education is still largely unexplored. This paper presents a research study which uses formal Lesson Study within an elective methodology course within their ITE programme. The process of Lesson study facilitated participating pre-service teachers (N=26) to explore the teaching and learning of STEM as it occurs in real live classrooms in conjunction with local schools in Limerick city. In particular, this paper focuses on participants' perceptions regarding the effects of participation in Lesson Study as well as their opinions regarding its particular features. This work also facilitates an exploration of knowledge demands of STEM teaching for pre-service and practising teachers as well as insights into children's reasoning as they engage in these innovative and inquiry-based units of instruction.

Keywords: STEM education; lesson study; pre-service teachers; initial teacher education

Developing Pedagogical Content Knowledge in Initial Teacher Education: Peer-Assisted Tutoring and Lesson Study

Aoibhinn Ní Shúilleabháin, Maria Meehan

School of Mathematics and Statistics, University College Dublin

Learning to teach is a long-term and complex enterprise (Morris, Hiebert, & Spitzer, 2009). In their commentary on initial teacher education (ITE), Hiebert, Morris, and Glass (2003) suggest that programmes are more valuable when they support pre-service teachers to acquire the tools they will need to learn to teach, rather than focus on achieving complete and polished competencies of highquality teaching. Peer-assisted tutoring and lesson study are models which can build pre-service teachers' awareness of the knowledge and skills required to teach, while also providing them with tools to continue their path as life-long learners (Amador & Carter, 2018). In this paper, we will discuss the incorporation of these two models, conducted in tandem during one semester, in the third year of a concurrent, undergraduate ITE programme in Science and Mathematics. Seven pre-service teachers volunteered to participate in this research and qualitative data, generated through planning documents and weekly reflections, was analysed utilizing the Mathematical Knowledge for Teaching framework (Ball, Thames, & Phelps, 2008). Findings suggest that due to their participation in peer-assisted tutoring and lesson study, these pre-service teachers developed important skills in noticing and reflection as part of their repertoire of learning to learn to teach. Furthermore, findings suggest a development of their knowledge of content and teaching (KCT) and knowledge of content and students (KCS) over the course of the semester. This research may provide useful insight for ITE providers and teacher educators.

Keywords: Initial teacher education, lesson study, peer-assisted tutoring

References

Amador, J., & Carter, I. S. (2018). Audible conversational affordances and constraints of verbalizing professional noticing during prospective teacher lesson study. *Journal of Mathematics Teacher Education*, 21, 5-34.

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content Knowledge for Teaching: What Makes It Special? *Journal of Teacher Education*, 59(5), 389-407.

Hiebert, J., Morris, A. K., & Glass, B. (2003). Learning to learn to teach: an "experiment" model for teaching and teacher preparation in mathematics. *Journal of Mathematics Teacher Education*, 6, 201-222.

Morris, A. K., Hiebert, J., & Spitzer, S. M. (2009). Mathematical Knowledge for Teaching in Planning and Evaluating Instruction: What Can Preservice Teachers Learn? *Journal for Research in Mathematics Education*, 40(5), 491-529. doi:10.2307/40539354

European STEM Schools Report: Key elements and criteria

Noelle Billon, Agueda Gras-Velazquez,

European Schoolnet, Brussels

In this presentation, we will share the results of an analysis developed to establish and validate the definition of a STEM (Science, Technology, Engineering and Mathematics) school. We will describe (1) which are the key elements and criteria that should be taken into account when defining a STEM strategy at school level, which would ultimately characterise a STEM School, and (2) how the different phases in the information-gathering process to select these key elements and criteria were developed. It responds to the fact that STEM education has become a priority in European countries and strategies are being developed to improve teaching and learning and the uptake of studies and careers in STEM. The information provided is based on a literature review and on consultations with four groups of key stakeholders in STEM education: schools, STEM teachers, Ministries of Education and STEM industries. The STEM school label elements and criteria have been developed within the framework of the STEM School Label project,co-funded by the Erasmus+ Programme of the European Union (Grant Agreement N. 2017-1-BE02-KA201-034748. The STEM School Label project will develop a framework where school representatives will be able to evaluate their school's performance in STEM via an online self-assessment tool, according to the set of criteria defining a STEM School from this report. This self-assessment tool will help schools identify required areas of development and will provide suggestions of resources for applicant schools to improve their STEM activities at school level.

The Future 'Vision' for Science Education: A Critical Analysis of the STEM Education Policy in an Irish Context

Nicola Broderick

Centre for the Advancement of STEM Teaching and Learning (CASTeL), Dublin City University

Policy pertaining to science education has come to the fore at global and national levels. Its importance as a panacea for economic success and global competitiveness has caused an international surge of curricular reform and the publication of numerous government reports, and Science Technology Engineering and Mathematics (STEM) policy documents. In Ireland, discourse of labour-shortage, decline in scientific graduates, and survival on an international scale has generated an impending STEM crisis. The quality of our workforce is being seen more and more as the most significant economic benefit to our society (Ball, 2008; Brown, Lauder & Ashton, 2008). It is within this context that the STEM Education Policy Statement (DES, 2017) was published in November 2017. With the STEM Education Policy having significant influence on future developments in science education: this policy deserves to be interrogated (Ball, 2003).

This presentation systemically analyses the STEM Education Policy Statement (DES, 2017) from inception to implementation. Robert's (2007) heuristic framework for analysing competing visions of scientific literacy, combined with the principles of Stephen Ball's Policy Cycle (Bowe, Ball, & Gold, 1992) form the conceptual policy analysis framework underpinning this presentation. Past developments in science education and the context in which the text was produced will be discussed. The emergence of the STEM crisis and initiation of the STEM policy will be traced. The policy text will be analysed to uncover the stakeholder's voices, power influences and government priorities. Finally possible interpretations, enactments and constraints of the policy will be explored. This presentation concludes that a re-envisioning of science education is required; where science education for all students is prioritised.

References

Ball, S.J. (2003). The teacher's soul and the terror of performativity. *Journal of Educational Policy, 18* (2), 215-228. Retrieved from http://www.tandfonline.com/doi/abs/10.1080/0268093022000043065

Ball, S.J. (2008). *The education debate.* Bristol: Policy Press.

Bowe, R., Ball, S.J., & Gold, A. (1992). *Reforming education and changing schools: Case studies in policy sociology*. London: Routledge.

Brown, P., Lauder, H. & Ashton, D. (2008).Education, globalization and the future of the knowledge economy. *European Educational Research Journal, 7* (2), 131-156. Retrieved from https://core.ac.uk/download/pdf/8809658.pdf

DES. (2017). *STEM education policy statement: 2017-2026.* Dublin*:* Government Publications. Retrieved from https://www.education.ie/en/The-Education-System/STEM-Education-Policy/stem-education-policy-statement-2017-2026-.pdf

Roberts, D. A. (2007). Scientific literacy/science literacy. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 729–780). Mahwah: Lawrence Erlbaum Associates.

Keywords: STEM education policy, Science education, Scientific literacy

Accrediting pre-service teachers' innovative practice in primary science within an ITE programme: Why and How?

John McCullagh, Andrea Doherty

Stranmillis University College Belfast

Various reports indicate that the profile of science and technology in primary schools has decreased in recent years. As with what is happening in the primary school curriculum, science can seem squeezed within an already crowded initial teacher education programme. Insufficient time and resources for developing pre-service teachers' confidence and competence in teaching primary science may significantly compromise the quality of science provision in our schools. This situation is exacerbated by the fact that often pre-service teachers have limited opportunities to teach, or even observe, science lessons during placement. This presentation will provide a rationale and a description of a degree enhancement accreditation scheme for primary science. Based on the Primary Science Teaching Trust's (https://pstt.org.uk/) 'Teachers' College' model the accreditation requires student teachers to evidence their competence in teaching, disseminating and engaging with the policy and theory which underpin their practice. The students are provided with opportunities to fulfil the criteria by engaging in science through a number of curriculum development projects with partner schools, dissemination seminars and an annual student conference. The skills and experiences gained through the course of the accreditation are designed to develop student teachers' sense of efficacy and agency and provide opportunities for them to network with schools in their community. As well as going some way to enhancing the current quality of science education, the scheme aims to nurture the potential science leaders of the future.

Keywords: Initial Teacher Education, Accreditation, Primary Science Education

How numerate are pre-service teachers?

Kathy O' Sullivan[1], Dr. Niamh O' Meara[1], Professor Merrilyn Goos[1], Professor Paul F. Conway[2]
[1] Epistem, School of Education, University of Limerick.

[2] Department of Education and Professional Studies, Faculty of Education and Health Sciences, University of Limerick, Ireland.

In recent years, numeracy teaching and learning has become a national priority in Ireland (DES, 2011). The Irish government have stressed the importance that numeracy teaching is the role of all teachers, not only the mathematics teacher. For this teaching strategy to be implemented effectively, we must ensure that teachers understand the complexity of the term numeracy and are aware of the various teaching strategies, methodologies and integrations of numeracy within their subject areas (DES, 2011; The Teaching Council, 2017).

The aim of this study was to investigate pre-service post-primary school teachers' understanding of the concept of numeracy and to test their numerate abilities. Data was collected from a sample of 23 first-year pre-service teachers enrolled in an initial teacher education programme in the University of Limerick. The instrument used in this study was a questionnaire which assessed pre-service teachers' beliefs and perceptions of the concept of numeracy and also assessed their numerate abilities. The pre-service teachers answered questions which determined whether they believed numeracy should be taught across the curriculum and also tested their confidence in numeracy teaching. The second part of the questionnaire consisted of six numeracy tasks where pre-service teachers demonstrated their mathematical knowledge and skills. All participants in this study rated themselves as having good or excellent numeracy skills, although the results of the second part of the questionnaire (numeracy tasks) stated otherwise. While all participants recognised the importance of numeracy in everyday life, it was only a minority who were able to complete the numeracy tasks which assess their numerate capabilities.

This presentation will present the results of the study, while also demonstrating that significant attention needs to be given to pre-service teacher's numeracy teaching and learning development. If Ireland, as a nation, intends to improve the numeracy skills of our young people, we must first equip our teachers with the necessary skills and understanding of numeracy.

Keywords: Numeracy, Pre-service Teachers, Across the Curriculum

References

Department of Education and Skills, 2011. Literacy and Numeracy for Learning and Life. *The National Strategy to Improve Literacy and Numeracy Among Children and Young People, 2011-2020*, pp.1–41.

The Teaching Council (2017). *Initial teacher education: Criteria and guidelines for programme providers*. Maynooth, Ireland: Author.

A temporal profile of students' attitudes to learning from a secondary school science classroom

Robert Clarke

University of Dublin, Trinity College Dublin

The Junior Cycle Science Curriculum Specification was implemented in September 2016 with the intentions of not only encouraging students to acquire a body of scientific knowledge about the world around them, but also to foster in them a lifelong interest for the subject by developing scientific literacy and habit of mind through 'activities that foster investigation, imagination, curiosity and creativity in solving engaging, relevant problems'. This inquiry orientation, combined with the key skills of junior cycle, aims to make students 'more self-aware as learners and become competent and confident in their ability to use and apply science in their everyday lives.' But how do students perceive the focus of their learning as they move through the system from Junior Cycle to Leaving Certificate? What do they regard as key objectives and targets for their attention? Is Diploma Disease and traditional rote learning experiences of the students' parents impacting on engagement with Learning How to Learn strategies? This presentation will discuss the results of research into students' perceptions of the subject, their cognitive readiness to effectively engage with it and their motivations to learn through 1st to 6th Year. It will also examine the differing attitudes of girls and boys from two cohorts of 2nd year students; the first from 2015, studying the previous Junior Certificate curriculum and the second from 2018, engaged with the current specification.

Key words: Resilience, Flow, Social constructivism, Diploma Disease, Self-determination theory, Creativity, Mindset orientation, Goal theory, Learning outcomes, Feedback and Assessment

References:

Black, P., McCormick, R., James, M., & Pedder, D. (2006). Learning How to Learn and Assessment for Learning: a theoretical inquiry. *Research Papers in Education*. 21(2), 119-132

Covington, M.V. (2000). Goal Theory, Motivation, and School Achievement: An Integrative Review. *Annual Review of Psychology*. 51(1) 171-200.

Csikszentmihalyi, M. (1992). *Flow: The Psychology of Happiness*. London: Rider.

Dore, R. (1997). *The Diploma Disease: Education, Qualification and Development*, (2nd ed.), London: Institute of Education, University of London.

Dweck, C.S. (2006). *Mindset*. New York, NY: Random House Inc.

Guay, F., Vallerand, R.J. & Blanchard, C. (2000). On the Assessment of Situational Intrinsic and extrinsic Motivation: The Situational Motivation Scale (SIMS). *Motivation and Emotion*. 24(3) 175-213.

Matthews, P. (2007). *The Relevance of Science Education in Ireland*. Dublin: Royal Irish Academy.

McCormack, L., Finlayson, O. & McCloughlin, T.J.J. (2009). *The Cognitive Developmental Levels of a Sample of First Year University Science Students*. CASTeL, Dublin City University.

Murphy, C., Murphy,C. & Kilfeather, P. (2011). Children Making Sense of Science. *Research in Science Education*. 41(2) 283-298

Government of Ireland. (2015). *Specification for Junior Cycle Science*. Ireland: Author

Improving problem-solving abilities of high achieving transition year students

Aidan Fitzsimons, Eabhnat Ní Fhloinn

School of Mathematical Sciences, Dublin City University

Catering for Gifted students within the regular classroom is an increasingly difficult task due to different students having different needs or ability levels, and it is certainly not a task capable of being accomplished without the backing of peers and school leaders – a complicated issue in Ireland. It is for this reason, amongst others, that the development of modules for these students is important. Through research into the concept of best practice for teaching gifted education, the author developed a mathematics module rooted in constructivist theory and employing the concept of Problem Based Learning (PBL). Students were given an open-ended problem to solve three times over the course of a fourteen week programme (in weeks 1, 8 and 13) and their attempts were graded using a detailed rubric (Oregon Department of Education, 2011). Over the course of the programme, students engaged in the solving of open-ended problems in groups with the author acting as a facilitator in the classroom. The test results were analysed using a paired t-test, evaluating any change in scores from week one to thirteen, but also week one to eight and eight to thirteen. In each of the three cohorts of students evaluated thus far, the scores showed that there was significant evidence to suggest students' problem solving abilities had improved.

Keywords: Problem solving, gifted, education.

References:

Oregon Department of Education (2011). *Mathematics Problem Solving Official Scoring Guide*. Accessed at http://www.oregon.gov/ode

Bringing Computational Thinking into STEM Education in Primary School

Margaret Leahy, Deirdre Butler, Deirdre Mc Quaid, Róisín Ryan, Francis Tormey,

Dublin City University, Institute of Education

Ireland

Computation and the development of computational thinking (CT) at primary level is an area of research that is still in its infancy and in critical need of research. Current debates centre on whether CT has become a battle cry for coding in primary education (Kafai, 2016), whether there should be a computer science curriculum for primary level with an explicit focus on CT (Angeli et al.; Fluck et al., 2016)? Or whether CT should be developed within the context of existing curricula at primary level (e.g. CSTA, 2011)?

From a constructionist perspective, computational thinking can be thought about in much the same way as Papert viewed computer programming; that is computational thinking is both a skill to learn and a way to learn –"to create, discover, and make sense of the world, with digital technologies as extensions and reflections of our minds". (Cator et al., 2018, p.21). Computational tools can be a powerful medium for creating contexts for constructing knowledge. However, in keeping with Papert's idea of engaging with "powerful representations", what is essential to consider when designing a learning environment is not so much what programming language and/or computational materials to use, but what personally meaningful ideas the programming language and materials can enable the children develop and how those ideas will develop computational thinking and form new ideas about the subject area (e.g. mathematics, science).

Against this backdrop, and drawing on research studies carried out by three primary school teachers, this presentation illustrates and discusses how the thoughtful use of computational tools within the mathematics and science curricula at primary level can both deepen learning of STEM content and provide a meaningful context within which CT can be developed.

Keywords: Computational Thinking; STEM; Teacher Education

References

Angeli, C., Voogt J., Fluck, A., Webb, M., Cox, M., Malyn- Smith, J., & Zagami, J. (2016). A K-6 computational thinking tramework-implications for teacher knowledge. *Educational Technology & Society*, 19 (3), 47-57.

Cator, K., Angevine, C., Weisgrau, J., Waite, C. & Roschelle J. (2018). *Computational thinking for a computational World.* Digital Promise. Retrieved: http://digitalpromise.org/wp-content/uploads/2017/12/dp-comp-thinking-v1r5.pdf

Kafai, Y. (2016). From computational thinking to computational participation in K-12 education. *Communications of the ACM*, Vol. 59 No. 8, Pages 26-27.

Fluck, A., Webb, M, Cox, M., Angeli, C., Malyn-Smith, Voogt, J. & Zagami, J. 92016). Arguing for computer science in the school curriculum. *Educational Technology & Society*, 19 (3), 38-46.

Computational Thinking via App Inventor – Lessons from the Irish Context

Monica Ward; Gary Conway; Julie Powers, Julie Regan

School of Computing, Dublin City University

Computational thinking, which involves abstraction and algorithmic thinking (Wing, 2006), is a key 21st century skill across many domains and it is a particularly important component of STEM subjects. App Inventor is a visual programming platform which can support computational thinking with K-12 students (Morelli et al., 2010). Dublin City University's (DCU) ComputeTY (ComputeTY, nd) program has been run successfully for many years and allows 15-17 year olds to learn computational thinking skills via App Inventor. The App Inventor team at DCU has developed and deployed blended App Inventor resources for teachers over a two-year period, with continuous modifications based on learner feedback. The resources aim to enable teachers to deliver an App Inventor course to their own students after they have gone through the learning practical learning experience themselves. These resources have been delivered to teachers and students in a variety of different formats: short workshops, 2-day workshops and a 10 week course. Computer Science has recently been introduced as an optional subject in the senior cycle of the Irish education system and there is a need for resources for the teachers who will teach this new subject, including out-of-field teachers. App Inventor can help to broaden and diversity participation in computing education (Wolber et al., 2015) which is an important priority for the DCU App Inventor team. This paper reports on lessons learnt during the process, how the resources can be used in the classroom and tips for teachers considering using App Inventor with their students.

Keywords: App Inventor, computational thinking, computing education.

References

ComputeTY, nd. ComputeTY - Computer Science to Secondary Schools. http://www.computing.dcu.ie/event/computety

Morelli, R., De Lanerolle, T., Lake, P., Limardo, N., Tamotsu, E. and Uche, C., 2011, March. Can android app inventor bring computational thinking to k-12. In Proc. *42nd ACM technical symposium on Computer Science Education* (SIGCSE'11) (pp. 1-6).

Wing, J. M., 2006. Computational thinking. *Communications of the ACM*, 49(3), pp.33-35.

Wolber, D., Abelson, H. and Friedman, M., 2015. Democratizing computing with app inventor. *GetMobile: Mobile Computing and Communications*, 18(4), pp.53-58.

Investigating students' learning of differential equations in physics.

Diarmaid Hyland[1,2], Paul van Kampen[2], Brien Nolan[1]

[1]CASTeL and School of Mathematical Sciences, Dublin City University, Dublin 9, Ireland.

[2]CASTeL and School of Physical Sciences, Dublin City University, Dublin 9, Ireland.

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 an *ordinary differential equation* (ODE).

This project is a multi-stage investigation that began by identifying the issues experienced by physics students during their study of ODEs before addressing them through the design and implementation of a set of fifteen tutorials. Having surveyed a cohort of physics students who completed a typical service module on ODEs, we found that many of them possessed a fragmented concept image of ODEs and insufficient instrumental understanding.

The workshop will outline the primary features of the intervention, one of which is the inclusion of modelling with first order ODEs. The participants will then be guided through the worksheets on modelling to experience the intervention from the students' perspective. The closing portion of the workshop will be a facilitated discussion that will begin with participant feedback on the worksheets before moving to tertiary service mathematics in general.

Keywords: Physics Education, Mathematics Education, Service Teaching

Developing Open Schooling in Ireland: Examining Schools as Evolving Learning Ecosystems

Paul Grimes[1], James Lovatt[1, 2], Eilish McLoughlin[1, 3], Caitríona Mordan[4], Padraig Murphy[4]
[1] Centre for the Advancement of STEM Teaching and Learning, Dublin City University

[2] School of STEM Education, Innovation and Global Studies, Dublin City University

[3] School of Physical Sciences, Dublin City University

[4] School of Communications, Dublin City University

Citizens today are required to have a better understanding of science and technology in order to help them to participate in science informed decision making and knowledge based innovation (Hazelkorn et al., 2015). One way in which schools can help to address this challenge is through the concept of Open Schooling. An Open School is an engaging environment that makes a vital contribution to the community. The Open Schooling approach aims to move beyond the constraints of present structures through supporting teachers in designing and implementing an Open Schooling model. This model promotes and encourages collaboration with non-formal and informal education providers, enterprises and civil society to ensure relevant and meaningful engagement of all societal actors with science (Louisoni, Istance and Hutmacher, 2004). We are in the initial phase of introducing Open Schooling in Ireland in the context of the Horizon 2020 project Open Schools for Open Societies. We have conducted interviews with school principals in order to assess where they perceive their school stands in relation to the characteristics of open schooling. This paper presents a framework for the analysis of these interviews, along with the initial findings from two of these interviews. We discuss the findings in the context of the needs and expectations of schools as they move towards becoming Open Schooling hubs.

Keywords: Open schooling, School leadership, Responsible Research and Innovation (RRI).

References

Hazelkorn, E., Ryan, C., Beernaert, Y., Constantinou, C.P., Deca, L., Grangeat, M., Karikorpi, M., Lazoudis, A., Casulleras, R.P. and Welzel-Breuer, M. (2015), Science education for responsible citizenship. *Report to the European Commission of the Expert Group on Science Education*.

Louisoni, P., Istance, D. and Hutmacher, W., 2004. Schooling for Tomorrow–What Future for Our Schools?. Prospects, 34(2), pp.163-175.

Connecting voices across disciplines: STE(A)M in Junior Cycle

Aine Woods, David King

Junior Cycle for Teachers (JCT) Support Service

The Framework for Junior Cycle (2015) advocates for professional development that promotes collaboration. A CPD programme for teachers and schools, led by JCT, is taking place against the backdrop of a number of other significant reform proposals in the STEM space. At a national level, the STEM Education Policy Statement 2017-2026 is underpinned by a number of principles, one of which acknowledges the interdisciplinary nature of STEM education (2017, p.9). In addition, Science Education for Responsible Citizenship (2015) offers a '21st Century vision' for Science education within the context of a broader European agenda and proposes a new framework for all types of Science education. It advocates for collaboration between formal and informal education providers and learning partnerships to promote active citizenry. To this end, the STEM Education in the Irish School System Report (2016, p.48) acknowledges the potential for intersection of STEM fields with the Arts in supporting cultural advancement and economic development opportunities. To support these ambitions, JCT launched the STE(A)M in Junior Cycle elective CPD initiative in November 2017. In this paper, we consider the realised and potential impact of this initiative in connecting the voices of teachers across disciplines, as well as connecting formal and informal CPD providers in the STEM and the Arts fields.

References

STEM Education Review Group (2016). *STEM Education in the Irish School System: A report on Science, Technology, Engineering and Mathematics (STEM) Education.* Retrieved from www.education.ie

STE_AM Education outside the classroom – a CPD model

Orla Kelly[1]; Tomas Aylward[2]; Yesim Tunali Flynn[1]; Janet McKennedy[3]
1 School of STEM Education, Innovation and Global Studies, Dublin City University

2 School of Health and Social Sciences, Institute of Technology, Tralee

3 School of Chemical and Pharmaceutical Sciences, Dublin Institute of Technology

Outdoor learning can be seen as a panacea to many current societal issues. It supports education for sustainability, it addresses concerns over children's mental and physical well-being and it offers an alternative to technology overload (Beames, Higgins & Nicol 2012). Furthermore, it can support the curriculum across early years and primary education (Waite, 2017). It aligns with the Better Outcomes, Brighter Futures Policy Framework for Children and Young People (DCYA, 2014). This paper describes a model of CPD which afforded initial teacher education (ITE) students to develop their own expertise in facilitating primary children learning outside the classroom through a mix of workshops, school-based learning and reflective tutorials. Following the workshops, the ITE students planned in small groups, with the support of an outdoor learning expert, four outdoor sessions to be delivered to 2nd class children in a local primary school. The ITE students completed questionnaires before starting the CPD, after the workshops and then again after the school based sessions and reflective tutorials. The questionnaires showed that the students' confidence and competence in supporting learning outside the classroom has increased and they were much more positive about teaching outside the classroom. The model of CPD will be critiqued and lessons shared for future CPD. While the ITE students were given free choice over curriculum areas to be taught, science with a strong environmental focus, as well as art, geography and PE were seen to be easily achieved and integrated outside the classroom.

Keywords: Outdoor learning, education for sustainability, CPD

References

Beames, S., Higgins, P. and Nicol, R. (2012). *Learning Outside the Classroom: Theory and Guidelines for Practice*. London: Routledge

DCYA (2014). *The National Policy Framework for Children & Young People 2014-2020*. Department of Children and Youth Affairs

Waite, S. (2017). Children Learning Outside the Classroom: From Birth to Eleven. London: Sage

WiSTEM2D: connecting Women in Science, Technology, Engineering, Math, Manufacturing and Design

Regina Kelly[1], Oliver McGarr[2] and Merrilyn Goos[1]
[1] EPI*STEM, University of Limerick,
[2] School of Education, University of Limerick

Recruiting more females into the STEM work force is an international goal. In 2016, the University of Limerick and Johnson and Johnson launched a global initiative to develop and implement high impact strategies to support female students undertaking Science, Technology, Engineering, Mathematics and Manufacturing Design degree courses. Exploratory research was conducted to investigate the 'climate' experienced by females students as they integrate into the often male male-dominated environment of STEM undergraduate courses. Females reported their peers were the most important support in third level, this exceeded academic supports. There were statistically significant differences between how male and female students identified with certain traits, with less females claiming to be intelligent and know about latest discoveries than males. To date, findings from this study recommend that work needs to be done in the higher education context, to increase socialisation of STEM females, to develop female students' self-awareness of their own capabilities and eradicate stereotypical views of scientists. Connecting females could act as a means to facilitate females adopting positive science identities, increasing their science capital. The prevailing culture and associated norms and practices of STEM programmes in higher education may need to be questioned in terms of whether they limit female students who do not initially identify with the discipline. By normalising stereotypical views and increasing female integration into a STEM culture, this will no doubt have a favourable effect on female participation in STEM.

Education for Sustainable Development through Inquiry-Based Science: Exploring a Programme of Professional Development for Irish Primary Teachers

Cliona Murphy[1], Greg Smith[1], Benjamin Mallon[2]
[1] Centre for the Advancement of STEM Teaching and Learning (CASTeL)
[2] Centre for Human Rights and Citizenship Education, Dublin City University

Education for Sustainable Development (ESD) aims to equip learners with the "knowledge, skills, values and behaviours needed for sustainable development" (UNESCO, 2018). Within Irish educational policy, ESD is positioned as a key approach towards addressing global issues, providing learners with "knowledge, dispositions, skills and values that will motivate and empower them to become active citizens and take measures to live more sustainably." (DES, 2014, p. 12). The potential contribution of science education towards ESD has been identified (e.g. Feinstein & Kirchglasser, 2015; Van Rijk & Roth, 2007; Zoller, 2012) and certainly science is recognized as an area of potential ESD integration within the Irish Primary Curriculum (DES, 2014; Ruane, Horgan & Cremin, 1999; Waldron & Pike, 2006). Existing research has explored the impact of science education professional development within the Irish context (Murphy et al., 2015a; Murphy et al., 2015b; Smith, 2014, 2015) and further afield (e.g. Fischer et al., 2018). To a lesser extent, research has begun to examine how ESD and similar educational approaches are addressed through Continuing Professional Development (CPD) programmes for teachers within the Irish context (O'Flaherty & M. Liddy, 2017; Tarozzi et al., Forthcoming). This paper draws upon research which examines the impact of a six month CPD programme for primary school teachers and focusses on the exploration of ESD through the lens of Inquiry-Based Science Education (IBSE). Utilising a mixed-methods approach, and drawing on pre- and post-programme surveys, in-depth interviews and participants' reflective journals, the paper considers the impact of one approach to CPD on the development of teachers' Pedagogical Content Knowledge (PCK) and self-efficacy in the area of ESD. Furthermore, the paper considers the extent to which CPD could support the integration of ESD into the Irish primary science curriculum and within a whole-school context.

Action Research Facilitating Belief Change for Out-of-Field Mathematics Teachers

Ciara Lane[1] and Máire Ní Ríordáin[2]

[1] EPI*STEM, School of Education, University of Limerick
[2] School of Education, University College Cork

Research on mathematics teachers' beliefs evokes a multifaceted link between a teacher's beliefs and his/her practices in the classroom. This is compounded for teachers of mathematics who are out-of-field (OOF) given that their beliefs may be shaped by their experiences in the classroom. A Professional Diploma in Mathematics for Teaching (PDMT) was designed and implemented from 2012, to address the issue of OOF mathematics teaching in Ireland. As part of this two-year, part time PDMT, teachers are required to complete an action research project (n=576). Examining one's own practices is the core form of action research utilized in the PDMT (McNiff & Whitehead, 2006). Given the acknowledged relationship between teachers' beliefs and practices (Zhang & Morselli, 2016), teachers' action research projects are a natural facilitator for reflecting on, and possibly transforming, their beliefs about teaching and learning (Fives & Gill, 2015). In this study, we employ Valsiner's zone theory adapted from Goos (2012), as a framework for conceptualizing OOF teachers' changing beliefs and practices during their action research. Valsiner's Zone of Proximal Development (ZPD), Zone of Free Movement (ZFM) and Zone of Promoted Action (ZPA) provides a means for theorizing teachers' learning in their individual context. Teachers' action research papers were analyzed for evidence of reported beliefs and practices that relate to direct transmission and/or constructivism. The findings indicate the presence of both belief categories, with the action research project enabling a transition from direct transmission to constructivism through facilitating the opportunity for productive tensions to be created by OOF teachers, reconciling the ZFM/ZPA complex and enhancing teachers' development.

Keywords: Out-of-field teaching, Mathematics teaching, Beliefs, Practices, Action Research.

References

Fives, H. & Gill M. G. (2015). I*nternational Handbook of Research on Teachers' Beliefs*. London: Routledge.

Goos, M. (2012). Sociocultural perspectives in research on and with mathematics teachers: a zone theory approach. *ZDM Mathematics Education,* 45, 521–533.

McNiffe, J. & Whitehead, J. (2006). All You Need to Know about Action Research. London: Sage.

Zhang, Q. & Morselli, F. (2016) *Teacher Beliefs*. In G. Kaiser (Ed.) ICME-13 Topical Surveys: Attitudes, Beliefs, Motivation and Identity in Mathematics Education. An Overview of the Field and Future Directions (pp. 11–13). SpringerOpen.

The Evaluation and Design of Tasks by Science and Mathematics Pre-Service Teachers

Majella Dempsey[1], Ann O'Shea[2].

[1] Education Department, Maynooth University

[2] Department of Mathematics and Statistics, Maynooth University

The types of tasks that children engage with have been shown to influence their development (Jonson et al., 2014), and studies have shown that pupils spend the majority of their time in mathematics classes at secondary school working on tasks (Boston & Smith, 2009; Haggarty & Pepin, 2002). Jeffes et al. (2013) found that traditional approaches to teaching and learning were widespread at second level in Ireland and recommended that students engage with more tasks which require higher order thinking skills such as problem-solving and justification.

With this in mind, in 2015/2016 we designed a module for Science and Mathematics Education students in an Initial Teacher Education programme in Maynooth University. The module gave students opportunities to become familiar with task classification frameworks such as the Levels of Cognitive Demand framework of Smith and Stein (1998) and its counterpart for Science tasks (Tekkumru-Kisa et al. 2015). It also aimed to give them experience of designing their own cognitively demanding tasks and trying them out in real classrooms. In this talk we will report on quantitative and qualitative data gathered from surveys and interviews with the first three years of students who have taken this module. In particular, we will show evidence of the impact of the module on students' pedagogical content knowledge and on their teaching practice.

Keywords: Task design, Task classification, Initial Teacher Education.

References

Haggarty, L., & Pepin, B. (2002): An Investigation of Mathematics Textbooks and their Use in English, French and German Classrooms: Who gets an opportunity to learn what?, *British Educational Research Journal, 28*(4), 567–590

Jeffes, J., Jones, E., Wilson, M., Lamont, E., Straw, S., Wheater, R., & Dawson, A. (2013). *Research into the impact of Project Maths on student achievement, learning and motivation: final report*. Slough: NFER

Jonsson, B., Norqvist, M., Liljekvist, Y., & Lithner, J. (2014). Learning mathematics through algorithmic and creative reasoning. *The Journal of Mathematical Behaviour, 36*, 20–32

Smith, M.S., & Stein, M.K. (1998). Selecting and Creating Mathematical tasks: From Research to Practice. *Mathematics Teaching in the Middle School, 3,* 344–350

Tekkumru-Kisa, Stein, M.K, & Schunn, C. (2015). A framework for analysing cognitive demand and content–practices integration: Task analysis guide in Science. *Journal of Research in Science Teaching*, 52(5), 659-685.

PRiME: A project to promote subject leadership in primary mathematics among student teachers

Maurice OReilly, Thérèse Dooley, Paul Grimes,
Lorraine Harbison and Aisling Twohill

School of STEM Education, Innovation and Global Studies, Dublin City University

In the final year of their BEd degree in DCU, prospective primary teachers who have chosen to take mathematics as their Major Specialism are required to take a module in Subject Leadership (Mathematics). This module ran over twelve weeks (October-December) in 2017, for the third time. Funding (through DCU Teaching & Learning) was made available to promote inquiry and project-based learning. This stimulated re-conceptualising assessment for the module; the focus of the main assessment element shifted to project work where the 23 students, taking Mathematics as their Major Specialism, were required to work with their non-mathematics specialist peers. The 23 collaborated (in groups of two or three) on clearly defined projects, one being chosen by each group from a suggested list, but with the detailed specification developed by the students over several weeks. Each group was required to organize an event with volunteer participants (from the remaining 376 final year BEd students) and gather data from the event. The project, event, data, findings and recommendations that arose were all summarised and presented in poster form, initially in a seminar setting and then in an exhibition space. The team of five lecturers involved in supporting students' project work gathered and analysed data, under the title Project in Rich Mathematical Exploration (PRiME), drawn from the posters themselves and from students' reflections on their work. This paper outlines the main elements of PRiME, and reports on the initial findings and the direction of the team's research.

Keywords: Subject leadership, Primary mathematics, Project-based learning, Peer collaboration.

The RDS STEM learning programme: Challenging science facilitation

Karen Sheeran[1], Sandra Austin[2], Odilla Finlayson[3], Maeve Liston[4], Tom McCloughlin[3], Cliona Murphy[3], Greg Smith[3]

[1]RDS, Dublin; [2] Marino Institute of Education, Dublin; [3]CASTeL, DCU, Dublin; [4]Mary Immaculate College, Limerick, Ireland

A dedicated in-career professional development programme was developed 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. A series of ten workshops, delivered over six months, focused on the following topics: Encouraging Creativity in Science, Developing Students' dialogical and thinking skills through Science, Integrating Science and Mathematics in the Classroom, Using Design and Technology in the Classroom, Guiding Child-Led Investigation, Exploring Children's Ideas of Science, and Investigating Everyday Issues in Science. The workshops were grounded within Social Constructivism, Inquiry Based Science Education (IBSE), Nature of Science, and Cognitive Acceleration through Science Education (CASE) methodologies. The cohort of teachers who attended these workshops were then tasked with developing and delivering a series of 8 workshops to other primary teachers. Analysis of the development of the initial cohort of teachers was reported through Reaction and Reflection sheets. This contrasts with what the group selected as important for the school based workshops and further with Reaction and Reflection Sheets from the school based teachers.

Increased confidence in teaching science by all the participants was evident after analysis of the data collected; this greater confidence reflected a greater understanding of both the scientific skills and knowledge as well as pedagogical knowledge. The extent of theoretical background knowledge to alternative pedagogies is discussed in relation to both sets of teachers.

Keywords: Primary science teacher, Professional development

A Q methodology approach to exploring second level students' perceptions of science teaching, learning, and assessment.

Niamh Burke

Maynooth University, Ireland

This presentation will report on data gathered through a Q sorting activity carried out with second level students from Ireland and Scotland. Data were gathered as part of an ongoing PhD project comparing the implementation of formative assessment in Ireland and Scotland. One of the key objectives of the study is to consider students' beliefs about teaching, learning and assessment within science to identify what factors influence their learning; this objective will be achieved through the Q methodology (see Brown, 1993; McKeown & Thomas, 2013). A total of 48 students took part in a Q sorting exercise with the researcher. The activity was conducted on a one to one basis and consisted of students ranking 48 statement cards onto a placemat containing a continuum from strongly agree to strongly disagree. Following the Q sort the researcher and each student engaged in a short interview where students were asked to discuss their sortings in relation to science teaching, learning and assessment. Quantitative analysis is proceeding with a factor analysis of the Q sorts. The qualitative data from the student interview will be analysed using a general inductive approach. At present, data analysis is not yet complete however, initial findings indicate that students' awareness of their learning in science lessons was ranked very highly, signifying their teachers' strong understanding of clarifying and sharing learning intentions, and criteria for success. Furthermore, initial student data denotes their awareness of the importance of quality feedback in their learning, and that teachers who are high quality formative assessment practitioners provide them with this.

Keywords: Formative assessment, Q methodology, Student subjectivity, Mixed methods.

References

Brown, S. (1993). *A Primer on Q Methodology*. Operant Subjectivity, 16(3/4), 91–138.

McKeown, B., & Thomas, D. B. (2013). *Q Methodology (2nd Edition).* Newbury Park: .SAGE Publications.

Conceptual change in upper second level electrostatics – The use of structured inquiry.

Richard Moynihan[1,2,4] Paul van Kampen[2,4], Odilla Finlayson[3,4], Eilish McLoughlin[2,4]
[1] O'Carolan College, LMETB, Meath, Ireland.

[2] School of Physical Sciences, Dublin City University

[3] School of Chemical Sciences, Dublin City University

[4] Centre for Advancement of STEM Teaching and Learning (CASTel), Dublin City University

The non-contact nature of electrostatic interactions was once a mystery to physicists until the concept of the field was developed. Students in upper level secondary education are introduced to electric fields, are required to represent them using both vector arrows and field lines. However, it has been shown that numerous difficulties and misconceptions are present in learners understanding of the field model at both second level and third level (Galili, 1993; Törnkvist, et al., 1993; Cao & Brizuela, 2016)

This small body of research presents results from a section of a case study completed with 14 upper second level students, in which structured inquiry tutorials representations to promote the students conceptual understanding field lines. Pre-test and post-test results are used to identify student difficulties and indicate the extent to which conceptual change occurs (Hewson, 1992). Instances from the tutorial lessons are presented to illustrate instances in which conceptual change is observed, based on the necessary conditions set out by Posner, et al, (1982). The discussion provide a commentary on the development of the students understanding of the field line representation, and how they used it to predict and explain the behavior of charged bodies acting under the influence of an electric field. Implications for teaching, focusing on the use of structured inquiry in the upper second level classroom are discussed in the conclusion of this small body of research.

Keywords: Electrostatics, Structured, Inquiry, Conceptual, Change

References

Cao, Y., & Brizuela, B. M. (2016). High school students' representations and understandings of electric fields. *Physical Review Physics Education Research, 12(2), 020102.*

Galili, I. (1993) Perplexitiy of the field concept in teaching – learning aspect. In *Proceedings of the Third International Seminar on Misconceptions and Educational Strategies in Science and Mathematics*, Ithica, NY: Misconceptions Trust

Hewson, P.W. (June, 1992). Conceptual change in science teaching and teacher education. Paper presented at a meeting by the *National Center for Educational Research, Documentation and Assessment*, Ministry of Education and Science, Madrid, Spain.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accomodation of a Scientific Conception: Towards a Conceptual Change. *The Internation Journal of Science Education , 66 (2), 211 - 227.*

Törnkvist, S., Pettersson, K. A., & Tranströmer, G. (1993). Confusion by representation: On students' comprehension of the electric field concept. *American Journal of physics, 61(4), 335-338*

In support of open learning outcomes in leaving certificate chemistry: the curious case of the 'cross' experiment

John O'Reilly

University of Limerick

This paper presents the reflections of a teacher educator on the adaptation of a leaving certificate chemistry mandatory experiment (the 'cross' experiment) to an open/guided inquiry experience consistent with the interpretation of an open learning outcome based on rates of reaction. An 'open' learning outcome is holistic in nature and not overly prescriptive which can present challenges in interpretation and enactment.

The flexibility in the approach taken led to novel and fascinating findings (relating to both content and process learning, but the former in particular) in a class of 3rd year undergraduate science education students. Future work is planned to interview these students and analyse their work to determine the nature of their insights. The potential of open learning outcomes to support student self-regulated learning in developing a deeper understanding of the nature of science will be considered in the light of recent literature.

Finally, some reflections will be presented on the role of teacher education in supporting pre-service teachers in developing autonomy and agency as they work with open learning outcomes. I will argue that whatever challenges are associated with the difficulty in operationalising open learning outcomes in the curriculum, the teaching and learning gains are worth the inevitable cost.

Augmented Reality Mathematics App

Monica Ward[1]; Odhran Daly[1]; Joseph Travers[2]

[1] School of Computing, Dublin City University

[2]Institute of Education, Dublin City University

Augmented Reality (AR) is increasingly becoming an area of educational interest in recent years (Wu et al., 2012). This paper reports on a new AR app for mathematics that is aimed at 4 – 7 year olds, but could be used by older learners also. The app, which superimposes AR images on to a real world view, covers counting, comparison and size estimates. There is a series of questions for each topic. The app 'places' a certain number of cartoon characters on a table and the students have to count them. The students use two hands to hold the tablet and this 'encourages' them to count without using their fingers. The app also forces the students to count abstract objects – this is conceptually more difficult than real physical objects. With the comparison topic, the student must decide if the number of characters on the left-hand side is less than, greater than or equal to that on the right-hand side. This app provides students with a new and dynamic way of looking at mathematics. AR technology is continually evolving and as the technology improves more comprehensive apps will be developed. It is important that educational apps are pedagogically driven and research informed and Bronack (2011) argues that *how* the AR technologies support learning rather than the underlying technologies per se is what is important. There are still technical and pedagogical issues to resolve, but this app provides an interesting insight into what is possible with AR and early years mathematics education.

Keywords: Augmented Reality (AR), mathematics, young learners, app, primary school.

References

Bronack, S.C., 2011. The role of immersive media in online education. *The Journal of Continuing Higher Education*, 59(2), pp.113-117.

Wu, H.K., Lee, S.W.Y., Chang, H.Y. and Liang, J.C., 2013. Current status, opportunities and challenges of augmented reality in education. *Computers & Education*, 62, pp.41-49.

Blurring the boundaries between informal and formal science in the classroom

Claudia Fracchiolla[1,2]; Shane Bergin[1]
[1] School of Education University College Dublin
[2] Center for STEM Learning University of Colorado Boulder

This workshop is for attendees who wish to i) develop informal science activities (also known as outreach) or, ii) incorporate aspects of informal science activities into the formal classroom. Outreach programs are designed to be engaging How can we design them and while also making them effective and appropriate for classroom settings. In the workshop, we will work with participants on:

- Designing activities aligned with their own interests, their communities' interests, and curriculum needs.

- Defining the activities' goals, program content, and methods of evaluation. Discuss guidelines with the purpose that attendees will work on their ideas and getting feedback from fellow attendees and organizers. A. The focus of the workshop will be on big picture planning to establish a broader plan of action for the design of the types of activities.

The workshop will include discussion of challenges to assess informal science-like activities, and research in these environments. Again, organizers will present some guidelines or resources, but a significant amount of time will be used for the attendees to consider what will be the best assessment tools/practices for the program they designed.

Finally, we aim to connect people interested in facilitating research-driven informal science activities to build community and collaboration between such individuals who are often marginalized in their departments or whose efforts in informal are considered tangential to "formal" science activities. Workshop attendees will take away ideas about how to leverage effective design and assessment of informal settings towards increased resources and support in their local contexts.

Keywords: Informal science, Design-based implementation research (DBIR), teacher's professional development.

A Cognitional Theory for Mathematics Methodology on an Initial Teacher Education Programme

Cornelia Connolly[1] , Tom Cosgrove, Tony Hall[2]

[1] School of Education, National University of Galway

[2]School of Engineering, University of Limerick

This paper suggests that the philosophical work of Bernard Lonergan comprises a powerful resource particularly suited to underpin and inform the practice of action learning in the context of a mathematical methodology for initial teacher education. It is proposed that the cognitional theory of Bernard Lonergan provides a framework that is uniquely suited to guiding this dynamic interplay, concerned as it is with what Lonergan calls the 'realms of meaning' of theory, practice and interiority (Lonergan 1972; D. Coghlan, 2010; D. Coghlan, 2016) and which can be adopted for mathematics teacher education.

The three-fold Action Learning strategy presented reorients education away from the transmission of pre-formulated concepts and towards the engagement of the 'pure desire to know' of each student as it draws the pre-service teacher through the levels of cognitional process. Lonergan's emphasis, like a teacher's, is on the act or event of insight in the learner's mind.

Practical and higher order thinking and reflection, promoted by encouraging problem solving skills, is best supported by valuing and elucidating reflexively the process of inquisitive and creative enquiry (Mason, 1998). Mathematical problems provoke spontaneous common-sense enquiry. With tutor guidance, enquiry moves into the realm of theory, or scientific knowing, an approach which offers a rationale to students for learning mathematical topics (Hiebert et al., 1996; Prusak, Hershkowitz, & Schwarz, 2013) and lastly to reflection and critical knowing. Lonergan's approach focusses on the student's framing fruitful questions rather than always reaching right answers. The cognitional theory provides teachers, preservice teachers and students with a guide to bring cognitional process into conscious awareness (Carley, 2005; Colleran, 2002; Connolly, Murphy, & Moore, 2008) and can be adopted for the mathematics ITE programmes.

References

Carley, M. T. (2005). *Creative learning & living : the human element.* Montréal: Thomas More Institute Papers.

Coghlan, D. (2010). Interiority as the Cutting Edge between Theory and Practice: A First Person Perspective. *International Journal of Action Research*, 6(2-3), 288-307.

Coghlan, D. (2016). Retrieving the philosophy of practical knowing for action research. *International Journal of Action Research (e-Journal)*, 12(1), 84-107.

Colleran, C. N. (2002). *Improving Adults' Quantitative Problem Solving Skills: Theory, Context and Programme Design.* (PhD), University of Limerick

Connolly, C., Murphy, E., & Moore, S. (2008). Programming Anxiety Amongst Computing Students—A Key in the Retention Debate? *IEEE Transactions on Education*, 52(1), 52-56. 2

Hiebert, J., Carpenter, T. P., Fennema, E., Fuson, K., Human, P., Murray, H., & Wearne, D. (1996). Problem Solving as a Basis for Reform in Curriculum and Instruction: The Case of Mathematics. *Educational Researcher*, 25(4), 12-21. doi: doi:10.2307/1176776

Lonergan, B. (1972) *Method in Theology*, London: Darton, Longman and Todd.

Mason, J. (1998). Enabling Teachers to be Real Teachers: Necessary Levels of Awareness and Structure of Attention. *Journal of Mathematics Teacher Education*, 1(3), 243- 267.

Prusak, N., Hershkowitz, R., & Schwarz, B. B. (2013). Conceptual learning in a principled design problem solving environment. *Research in Mathematics Education*, 15(3), 266-285.

Teacher and student experience of inquiry in the context of SSI: A comparison of two approaches

Ruth Chadwick, Eilish McLoughlin, Odilla E. Finlayson

CASTeL, Dublin City University

In Ireland, students will be required to carry out an inquiry in the context of socioscientific issues (SSI), the Science in Society Investigation, in their third year of Junior Cycle (NCCA 2016). The study presented here explores the teacher and student experience of inquiry in the context of SSI, in preparation for the Junior Cycle Science in Society Investigation. Two case studies are presented which follow two teachers and their students. Data collection methods included teacher interviews and document analysis (student questionnaires, student work, teacher lesson documentation) and thematic analysis was carried out on all data (Braun & Clarke 2006). The teacher experience focused on the pedagogical approach used, which varied between the two teachers in terms of the type of inquiry: experimental or secondary research and discussion. This in turn affected the student experience, which focused on the skills and knowledge developed. The experimental approach to inquiry developed skills relating to "the scientific process", including questioning, hypothesising, planning and evaluating experiments, data analysis and drawing conclusions. The secondary research and discussion approach to inquiry developed skills relating to critical evaluation of evidence. The knowledge developed by students was context specific and related to the SSI explored, which also differed between the two teachers. This presentation will compare and contrast the two approaches in terms of the teacher and student experience, and SSI contexts explored. It will also discuss the implications for practice in terms of the implementation of the Irish Junior Cycle Science in Society Investigation.

Keywords: Socioscientific issues, Inquiry

References

Braun, V. & Clarke, V., 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology,* 3(3), pp. 77-101.

National Council for Curriculum and Assessment (NCCA), 2016. *Junior Cycle Science: Guidelines for the Classroom- Based Assessments and Assessment Task.* Ireland: NCCA.

Teacher as resource: How might the role of the teacher in fostering powerful mathematical and language practices be analysed?

Miriam Ryan

CASTeL, Dublin City University

Current research in the teaching and learning of mathematics in multilingual contexts has rejected deficit perspectives of multilingualism and focused on ideas of language as a resource (Planas, 2013), and sources of meaning (Barwell, in press). While students' uses of their multiple languages to support their mathematical learning have been documented, the role of the teacher in immersion pedagogy in developing and supporting these practices has been unexamined. The focus of this paper is to present a proposed methodology, informed by socio-cultural theories of learning, to identify and examine pedagogical actions which stimulate, support and enhance students' use of their languages to develop competence in the target mathematics and language. The potential use of this methodology to structure and inform an empirical investigation into the prevalence and nature of these teacher actions in the Irish-language immersion elementary school is presented and discussed.

Policy and practice in the use of multiple connected representations: Exploring primary and post-primary teacher practices in manipulative use in mathematics education

Niamh O'Meara[1] , Patrick Johnson[2] , Aisling Leavy[3]

[1] EPISTEM, School of Education, University of Limerick;

[2]School of Education, University of Limerick;

[3] Department of Language, Literacy and Mathematics, Mary Immaculate College

Research and policy advocate for the use of multiple connected representations to support the development of robust conceptual understandings in mathematics. While recommended representations vary based on content, age and developmental considerations; their theoretical and design underpinnings originate from Bruner's work on enactive, iconic, and symbolic modes of representation and take into account Concrete-Representation-Abstract instruction. This study explores the use of one form of representation, that of mathematical manipulatives, at a critical point in the educational transitional of mathematical learners - the transition from primary to post-primary education. We report on the outcomes of a survey of 450 teachers who teach students in their final year of primary school and 290 teachers teaching mathematics to students in their first year of post-primary school. Analysis of the survey data provide unique and valuable insights into the frequency of manipulative use at this critical transition for learners and highlights pedagogical discontinuities experienced by learners of mathematics. We explore the implications of these findings for teachers and learners of mathematics and provide suggestions to support teachers in their selection and the use of multiple connected representations for mathematics teaching.

Nature of Science in Initial Science Teacher Education: Illustrated Case Studies

Alison Cullinane,[1] Sibel Erduran,[1] Paul Conway [2]

[1]University of Oxford; [2]University of Limerick

A central component of scientific literacy is having an adequate understanding of the 'Nature of Science'. Developing NOS understanding is one of the most commonly stated objectives for science education. The importance of this objective has recently been addressed in the reform of the Irish Junior Cycle (middle school) Science curriculum, where 'Nature of Science' (NOS) is an overarching feature of all teaching and learning in the Science specification. Addressing NOS is now a key concern for initial teacher education (ITE) programmes in Ireland, as it will be pivotal to its successful incorporation in the science classroom.

To embark upon these reforms in ITE, workshops were designed to introduce pre-service teachers (PSTs) to NOS ideas, such as methods, practices and social institutional aspects. The study was theoretically underpinned by an NOS model by Erduran and Dagher, entitled the Reconceptualised Family Resemblance Approach to Nature of Science (RFN). This meta-perspective NOS model is open to transformation and presents a realistic view of science

Case study research design was implemented, to better understand how pre-serice teachers learn about NOS. Four cases were identified to inform how PSTs responded to the NOS professional development. Findings from the study suggest that the RFN framework was useful for improving and maintaining the PSTs NOS understanding and the meta-strategic lens used has the potential to provide PSTs with the skills to examine science explicitly and draw attention to NOS in their lessons. However, analysis of the data collected suggests that the PSTs had difficulty integrating NOS into their lesson planning and consequently explicit use of NOS in their lessons and instructional material developed was limited.

The 2018 STEM Discovery Week

Adrienn Pap, Róbert Baldursson, Evita Tasiopoulou, Noelle Billon, Agueda GrasVelazquez

European Schoolnet, Brussels

The STEM Discovery Week 2018 is a joint international initiative of projects, organisations and schools across Europe and around the world, celebrating careers and studies in the fields of Science, Technology, Engineering and Mathematics (STEM). The tagline for this year's campaign "say yes to STEM" described the partners' open-minded and dedicated support to STEM subjects at school, as well as wide-ranging collaboration among stakeholders in the area. Scientix coordinated this year's campaign in collaboration with the SYSTEMIC project, which is funded by the Erasmus+ programme of the European Union, and the STEM Alliance, which is a private funded initiative. Thanks to the support of additional partners, which brought originally together projects like PERFORM and STIMEY, in addition to 16 other projects in STEM education, with 38 organisations and 37 schools as official partners, the 2018 STEM Discovery Week reached over 800 activities organised by stakeholders in STEM education in 40 countries. In terms of impact, there were more than 120,000 teachers, pupils and other people interested in STEM education reached directly and there was an estimated indirect social media impact of 7.5 million people. During the event, there were also 160 blog posts published on the STEM Discovery Week blog coordinated by SYSTEMIC and 18 activities were streamed live from 23-27 April 2018, resulting in more than 61,000 views. In this presentation, we will share how the STEM discovery week was set up, outreach, type of activities organized, main results and lessons learned.

Supporting and enhancing the STEM and Arts capacity of primary teachers and schools

Colette Murphy[1], Alice D'Arcy[2], John O'Halloran[3], Fiona Naughton[4]

[1]School of Education, Trinity College Dublin

[2]STEAM-Education Ltd

[3]University College Cork

[4]STEAM-Education Ltd

In Ireland, STEM has been an area of increasing focus in recent years. In this project, we are directly addressing some of the proposed actions published in the recent STEM Review Group (2016) report, for example we:

• avail of partnerships with STEM enterprises to promote STEM careers at all levels in education.

• develop extensive curricular materials for teachers that operationalise learning outcomes in STEM subjects at primary/post-primary levels.

• promote and facilitate 'adoption' of a school, or cluster of schools, by a local STEM industry/enterprise.

STEAM-in-a-Box provides industry and academic professionals to coteach science, technology, engineering, arts and mathematics programmes with primary-school teachers. The professionals and teachers undergo induction in coteaching-pedagogy (Murphy, 2016), which aims at supporting them to share expertise in providing a stimulating, exciting, real-science learning experience for children. The programs run for an hour per week over a period of between 10 and 30 weeks. STEAM-Education-Ltd (http://www.steam-ed.ie/about.html) comprises a unique partnership that unites actors from STEAM research, science education research, formal and informal science education, artists, designers and industry with one vision - to excite, inspire, and educate primary school children in STEAM through a direct connection with frontier research and development.partnership between industry, schools and academia. We also provide additional resource materials, specially designed for class teachers, and are developing CPD in STEAM education. Our framework seeks to make a step change in STEAM education in Ireland through new investment and the leveraging of existing resources. The presentation will illustrate the theory and practice of this project.

Keywords: STEAM education, coteaching, primary science, inudtry-school-academic partnership

References

STEM Education Review Group (2016). *STEM Education in the Irish School System – a Report on Science, Technology, Engineering and Mathematics (STEM) Education*, posted at http://www.education.ie/en/Publications/Education-Reports/STEM-Education-in-the-Irish-School-System.pdf

Murphy, C. (2016). *Coteaching in Teacher Education*, Northwich: Critical Publishing Ltd ISBN: 978-1-910391-82-2

DiagnoseDys – a Dyscalcula diagnosis App

Monica Ward[1]; Méabh Horan[1]; Joseph Travers[2]

[1] School of Computing, Dublin City University

[2] Institute of Education, Dublin City University

Dyscalculia is a number module cognitive deficit (Landerl et al., 2009). Developmental dyscalculia (DD) has a prevalence of 3 – 6% and affects the acquisition of mathematic skills in children with normal intelligence (Kucian et al., 2011). In Ireland, the dyscalculia assessment process is currently a purely paper-based. Dyscalculia assessors work with children in the 4-6 year age range and gauge their comprehension of various mathematical concepts including counting, comparison, shapes and patterns. The assessor must go through a standardized diagnosis process, while in some cases simultaneously document the students' responses. The DC app is a tool to help in the dyscalculia diagnostic process. The DC app runs on a tablet or mobile phone and has two modes: student mode and teacher mode. In student mode, the student answers questions on a series of topics that replicate the current paper-based model. All the student's responses are stored in real-time. If the student passes a configurable threshold of correct answers, the system automatically moves on to the next set of questions. In teacher mode, the assessor can see data on each student on the assessor's dashboard in graphical format. The DC system has been designed and developed by computing and special education (mathematics) researchers. Two of the main advantages of the app are the elimination of manual data entry and the real time availability of results. Early indications are that while there is plenty of scope to improve the app, it has the possibility to be a useful tool for dyscalculia assessors.

Keywords: Dyscalculia, assessment, young learners, app, primary school.

References

Kucian, K., Grond, U., Rotzer, S., Henzi, B., Schönmann, C., Plangger, F., Gälli, M., Martin, E. and von Aster, M., 2011. Mental number line training in children with developmental dyscalculia. *NeuroImage*, 57(3), pp.782-795.

Landerl, K., Fussenegger, B., Moll, K. and Willburger, E., 2009. Dyslexia and dyscalculia: Two learning disorders with different cognitive profiles. *Journal of Experimental Child Psychology*, 103(3), pp.309-324.

Using the Knowledge Quartet to Analyse University Mathematics Teaching

Sinéad Breen[1], Maria Meehan[2], Ann O'Shea[3], and Tim Rowland[4]

[1]School of Mathematical Sciences, Dublin City University; [2]School of Mathematics & Statistics, University College Dublin; [3] Department of Mathematics & Statistics, Maynooth University; [4] Department of Teacher Education, Norges teknisk-naturvitenskapelige universitet, Norway.

The Knowledge Quartet (Rowland, 2013) is a theoretical tool for observing, analysing and reflecting on how a teacher's knowledge of mathematics and mathematics pedagogy influences his/her actions in the classroom. Although it emerged from empirical research on mathematics lessons at primary level, the Knowledge Quartet has also been used to study mathematics teaching at secondary level. Here we consider how the framework could be used to study university level teaching, and report on the dimensions of teacher knowledge that were made visible by the use of this framework.

The data used for the study were accounts written by three mathematics lecturers on their teaching practice. The accounts focus on notable incidents that occurred during teaching, and take the form of 'brief-but-vivid' accounts as advocated by the Discipline of Noticing (Mason, 2002). Our analysis has shown that all four dimensions identified by the Knowledge Quartet (foundation, transformation, connections, contingency) were present in the accounts examined. However, there are some differences in the prevalence of the codes (within each dimension) assigned in this study compared with previous studies at school level. Nevertheless, we found the framework provided a useful lens through which the knowledge brought to bear in the preparation and teaching of university mathematics lectures could be viewed in a coherent and comprehensive manner. Furthermore, we suggest that the use of the Knowledge Quartet as a reflection tool could afford mathematicians who teach university mathematics (with no formal pedagogical training) an opportunity to develop pedagogical knowledge to enhance their teaching practice.

Keywords: Knowledge Quartet, teacher knowledge, university mathematics teaching.

References

Mason, J. (2002). *Researching Your Own Practice: The Discipline of Noticing.* London: Routledge Farmer.

Rowland, T. (2013) The Knowledge Quartet: the genesis and application of a framework for analysing mathematics teaching and deepening teachers' mathematics knowledge. *SISYPHUS* Journal of Education, 1(3), pp. 15-43

Undergraduate Mathematics: Engagement in Live Lectures versus Flexibility of Online Videos

Emma Howard[1] , Maria Meehan,[1]Andrew Parnell[1],[2]

[1] School of Mathematics and Statistics, University College Dublin

[2] Insight Centre for Data Analytics, University College Dublin

Recently, there have been numerous studies focusing on students' resource usage at undergraduate level (Inglis et al., 2011; Marinos, Robinson and Lerman, 2017; McKenna and Kopittke 2018). While many of these studies concentrate solely on the patterns of resource usage that occur, we are also interested in why these patterns transpire. In this talk, we present results from a study conducted with students enrolled on the 2015-16 offering of Maths for Business, a large first-year undergraduate module (n=522), where students have the choice of accessing the module content through live lectures or online videos or both (Howard, Meehan & Parnell, 2017). We aimed to identify patterns of resource usage and explore the reasons why students chose to use particular resources. Using cluster analysis, we found four patterns of resource usage within the entire student cohort: Dual-Users, Lecture-Users, Video-Users, and Switchers. Through thematically analyzing survey data (n=161), we identified the following factors which influence students' resource usage: flexibility, scheduling and pace, ability to ask questions, reinforcement of topics and engagement with livelectures. Students with low prior mathematical achievement, based on Leaving Certificate Mathematics results, particularly benefitted from using both resources (Dual-Users), whereas, those with high prior mathematical achievement could achieve high marks using either resource. We propose that providing students the choice of live lectures or/and online videos is a beneficial system to approaching teaching in large mixed-ability cohorts at undergraduate level. In addition to the paper content, we will comment on how students study in general for their weekly quizzes.

Keywords: Undergraduate mathematics, Live-lectures, Online-videos, Resource usage.

References

Anastasakis, M., Robinson, C. L. and Lerman S. (2017) Links between students' goals and their choice of educational resources in undergraduate mathematics. *Teaching Mathematics and its Applications: An International Journal of the IMA*, 36(2), pp. 67– 80.

Inglis, M., Palipana, A., Trenholm, S. and Ward,J. (2011) Individual differences in students' use of optional learning resources. *Journal of Computer Assisted Learning*, 27(6), pp. 490–502.

Howard E., Meehan, M. and Parnell, A. (2017) Live lectures or online videos: students' resource choices in a first-year university mathematics module. *International Journal of Mathematical Education in Science and Technology*, 49(4), pp. 530-553.

McKenna, B. and Kopittke, P. (2018) Engagement and performance in a first year natural resource science course. *Journal of Computer Assisted Learning*, pp. 1-10. Advance online publication. doi: 10.1111/jcal.12236

The Development of a Framework to Assess Technology Enhanced Resources for Mathematics Education

Caitríona Ní Shé[1], Ciarán Mac an Bhaird[2], Eabhnat Ní Fhloinn[1], and Ann O'Shea[2]

[1]Dublin City University, [2]Maynooth University,

A recent OECD report (September 2015) questioned the value of computers in education and made a claim that there was in fact negative correlation between performance in mathematics and the use of computers in teaching mathematics. However there are counterclaims, such as research reported by Ronau et al. (2014) who found that digital calculators and computer software do improve student understanding. In a review of recent research in this area Drijvers (2016) suggested that we need studies that focus on the 'decisive factors' that establish 'eventual benefits'. King et al. (2014) suggested that the lack of theoretical frameworks of evaluation have hindered the gathering of evidence to support the use of technology in education.

As part of a project funded by the National Forum for the Enhancement of Teaching and Learning (NFETL), a number of technology-enhanced formative assessment resources were developed to support the teaching and learning of mathematics in first year service mathematic modules. To help evaluate the effectiveness of these resources and to addrress the issues outlined by Drijvers (2016) and King et al. (2014) we developed a theoretical framework. This framework, called the Technology-enhanced Resources for Mathematics Education (TeRMEd) framework, draws on existing classification frameworks as well as incorporating new categories of classification.

In this presentation, we will describe the TeRMEd framework and how we developed it, as well as demonstrating an example of how it can be used.

References

Drijvers, P., Ball, L., Barzel, B., Heid, M. K., Cao, Y., & Maschietto, M. (2016). Uses of Technology in Lower Secondary Mathematics Education. In *Uses of Technology in Lower Secondary Mathematics Education* (pp. 1-34). Springer, Cham.

King, M., Dawson, R., Batmaz, F., & Rothberg, S. (2014). The need for evidence innovation in educational technology evaluation. In Uhomoibi, J. et al. (eds.) Proceedings of INSPIRE XIX: Global Issues in IT Education, Southampton, pp. 9 - 23.

OECD. (2015). *Students, computers and learning: Making the connection*. Retrieved from http://www.oecd-ilibrary. org/education. doi:10.1787/9789264239555-en

Ronau, R. N., Rakes, C. R., Bush, S. B., Driskell, S. O., Niess, M. L., & Pugalee, D. K. (2014). A survey of mathematics education technology dissertation scope and quality: 1968–2009. *American Educational Research Journal*, 51(5), 974-1006.

The Rule of 3: A Scaffold for Teaching Chemical Maths

Natalie O'Neill

School of Education, Maynooth University

This aim of this presentation is to show how a difficult topic such as stoichiometry can be simplified using a scaffolded method of instruction so that the chemical maths involved is made more accessible to those working with and studying chemistry. On reading the recommendations from the chief examiner for candidates who sat the Leaving Certificate Chemistry exam this year (2017), she notes that, "Candidates are finding volumetric calculations based on first principles difficult" (PDST, 2017). Her advice to all candidates was to "practice calculations". Using a simple concept based on ratio and proportion called the Rule of 3 reduces the working memory demands on students without relying on algorithmic problem solving methods; which require application of pre-existing procedures where learning and problem solving may not occur (Shuell, 1990). Vygotsky (1978, p.56) believes that development of problem solving functions proceeds in a spiral fashion, "passing through the same point at each new revolution while advancing to a higher level." This is *exactly* what the Rule of 3 allows the student to do. When used consistently, students can solve more and more difficult calculations while still referring back to the same point (Rule of 3) at each new revolution. If we take the Rule of 3 as a scaffold for teaching stoichiometry and teach students first how to use it effectively and then how to apply it to stoichiometric calculations, they can become adept at problem solving for chemical maths.The idea behind the Rule of 3 is not a new one but when it is applied to chemistry, it opens up a world of understanding for students and reduces their dependence on memorising tables and formulae.

Keywords: Rule of 3, Scaffold, Vygotsky, Stoichiometry.

References

Professional Development Service for Teachers (2017), *2017 Exam Statistics 1*, www.pdst.ie, accessed: 19/02/2018

Shuell, T. J. (1990). Phases of meaningful learning. *Review of educational research*, *60*(4), 531-547.

Vygotsky, L. S. (1980). *Mind in society: The development of higher psychological processes*. Harvard university press