



**BSRLM Conference Abstracts**  
**The Mathematical Institute, University of Oxford**  
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*Prospective mathematics teacher noticing: A focus on students' difficulties with Function concept*

The aim of this study is to investigate prospective mathematics teachers' (PMTs) noticing skills with regard to students' difficulties with function concept. Participants are fifteen upper secondary PMTs who were enrolled in a teacher preparation program. Participants watched videos of three episodes from three different lessons on functions and used an observation form to describe three important events of the lessons and offer approaches different from that of the teacher in the video. Observation forms were analysed using content analysis. Themes were specified concerning three most important events described by PMTs. The findings will be discussed to discover the way in which participants address students' difficulties with function concept.

Key words: *noticing; function concept; prospective mathematics teachers*  
Session type: *Research paper*  
Duration: *30 minutes*

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*Observations about some UK primary teaching that has been influenced by the mastery agenda*

From 2014, the UK government has been financing exchange visits between English and Shanghai teachers of mathematics in primary schools. The political thinking behind the decision was that, despite major differences in training, workload and cultural background, primary school teachers could change their teaching to the methods employed by teachers in Shanghai and use a 'mastery' approach. The political intention may have been to alter pedagogy, that is the environment, expectations and practices of teaching. However, a major difference observed by the English teachers is the grain size of the focus of lessons, the Shanghai teachers focusing on critical aspects of a mathematical idea where the English teachers have been used to working with varied pedagogy on varied pedagogy on broader conceptual areas. In this paper, we use variation theory as a tool to analyse part of a lesson which was developed after the teacher observed lessons in Shanghai and placed, through the NCETM website.

Key words: *mastery; variation; primary mathematics teaching*  
Session type: *Research paper*  
Duration: *60 minutes*

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*Trainee teachers' perceptions of solving word problems and the bar-model as a strategy to support children in solving word problems*

Problem solving is one of the three main aims of the National Curriculum for Mathematics in England, but the



literature suggests that solving word problems can be difficult for many children. The bar model is a strategy used in Singapore to bridge the gap between the word problem and the symbolic representation of the solution. It has recently been introduced to some primary mathematics classrooms in England. As a new teacher-educator researcher, I was interested in how my group of PGCE trainee teachers perceived the bar model as a strategy for supporting children in solving word problems. Findings, which are pertinent to this study, suggest that some trainee teachers experience the same issues in solving word problems as children and that the introduction of the use of the bar model should be structured alongside the teaching of key mathematical concepts rather than as a discrete topic.

Key words: *teacher training; problem solving; bar model; perceptions*  
Session type: *Research paper*  
Duration: *30 minutes*

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*Replication of a British study in Brazil: How do teachers describe mathematical tasks?*

Foster and Inglis (2017) used factor analysis to investigate how mathematics teachers qualify classroom tasks. Based on 360 answers to an online survey, they identified seven factors underlying a comprehensive set of adjectives and expressions commonly used to describe mathematical tasks. This part of their study was replicated by the authors of this session with about 400 Brazilian teachers and the results presented many similarities and some interesting differences with the British context. For instance, our analysis also suggested seven factors, but only four were similar to factors identified in the original study. In this session, we will discuss the main results of both studies, highlighting their similarities and differences.

Key words: *mathematical tasks; adjectives; factor analysis; replication*  
Session type: *Research paper*  
Duration: *30 minutes*

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*How to look and what to see*

As a new researcher in mathematics education, I am seeking to work through the ontological and epistemological challenges associated with setting aside the modes of observing that I have assumed, consciously or otherwise, and seeing in other ways. In this workshop, I will present accounts of the same classroom episode constructed with different observation protocols and invite reflection on the mediating effect of the protocol and observer. These will be compared with a direct viewing of the same episode, allowing for discussion of what has and has not been seen and what might be distilled as of wider interest, following Jaworski's guidelines for use of video excerpts – giving an 'account of' before 'accounting for'. In this context, I will present a possible framework in which to observe elements of 'mastery' and share some of the challenges in its application in secondary-school classrooms.

Key words: *mathematics lesson observation; mastery; epistemology; ontology*  
Session type: *Research workshop*  
Duration: *60 minutes*



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*Understanding the complexities of teachers' knowledge and practice for dynamic technology use in lower secondary mathematics: Implications for sustainability and scaling*

We report the findings from the 2-year Nuffield-funded project that has researched teachers' knowledge and practice for teaching with dynamic mathematics technology at Key Stage 3. We used the framework 'Mathematics Pedagogical Technology Knowledge' to identify components of teachers' knowledge that seem key to the development of their confidence (and ability) to teach with technology, made visible through: responses to MKT items and PD tasks; lesson plans and lesson observations. In this workshop we will include some tasks for discussion, supported by contrasting lesson plans and clips of classroom practices taken from the 'PD Toolkit' - a research-informed resource for school-based professional development to support further scaling and sustainability after the project has ended.

Key words: *dynamic mathematics technology; 11-14 years; teacher knowledge and practice; scaling and sustainability; professional development*  
Session type: *Research workshop*  
Duration: *60 minutes*

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*'Building and Sustaining Active Research Collaborations with Teachers of Mathematics' Working Group*

This firmly established BSRLM working group will meet to continue to explore collaborations between teacher and researchers in the processes of doing, reflecting upon and engaging with the findings, of mathematics education research. We welcome new participants to the group, which is informal and invites participants to discuss these themes within the context of their individual work. A sub-group will continue to discuss, critique and work on the communication of 'research outputs' for the BSRLM BLOG. Teachers are particularly welcome to join the group and join discussions about what is of current concern to them, and how this might best be communicated.

Key words: *collaborative research; teacher inquiry; research-informed practices*  
Session type: *Working group*  
Duration: *60 minutes*

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*How primary trainee teachers' beliefs change about mathematics education during their first term of a PGCE course*

Within the UK, it is widely acknowledged that there are not enough good teachers of mathematics and that this is having an impact on different facets of society, including confidence, job prospects and the economy. Reasons behind this need to be explored so that this trend can be reversed. This session will explore the experiences of three Primary Trainee Teachers within the world of mathematics education. Their perceptions, confidence and attitude of mathematics education are explored at different points during their PGCE Primary teaching course to discover whether university led subject knowledge/pedagogy sessions and teaching children on placement can change these views in a positive way. Using the framework of the 'Knowledge Quartet', I analyse whether the



beliefs of the trainees have changed and why, in order to use this knowledge to inform future practice for the successful teaching and development of future trainees. From this, further issues are exposed which are worthy of future research.

Key words: *primary; trainees; beliefs; mathematics education*  
Session type: *Research paper*  
Duration: *30 minutes*

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*Singapore bar models appear to be the answer, but what then was the question?*

The recent interest in mathematics teaching in jurisdictions that do well in PISA and TIMSS tests has highlighted mathematics teaching in Singapore in particular, their use of bar models to support problem solving. As this heuristic is becoming more widely used in many schools, research was undertaken in a primary school where the children were unfamiliar with bar models to examine if they had successful problem solving strategies and to what extent they used 'drawing a diagram' as a heuristic. The research was undertaken with a small group of Year 6 pupils in an urban primary school. Data was collected through observations, discussions and the written jottings produced by the children. The study showed that pupils were successful in solving problems without using bar models. However, it also showed that they used a wide range of diagrams, some taught, some idiosyncratic, for different purposes, at different points within the problem solving process. This raised the question, if bar models are the answer, what question are they answering in terms of mathematics pedagogy.

Key words: *bar models; problem solving; heuristics*  
Session type: *Research paper*  
Duration: *30 minutes*

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*On learning number: The strange case of 20*

In this session, we will draw on data collected over an academic year in a school in the UK in which one author was asked to support the lowest attaining child in Year 2, in number work. Video recordings of thirteen one-to-one sessions were taken and these are analysed through a focus on the number concepts that are worked on (including the –teens and 20). The number 20 was chosen as one focus for analysis because it was a number that the student was not able to name in the first session and because it remained a problematic number throughout the sessions in terms of naming and writing. Through our analysis we detail confusions between –teen and –ty numbers (e.g., 'fourteen' and 'forty') that appear persistently, in different ways, across all sessions. Despite this confusion, the student was confident at many aspects of number naming beyond twenty and showed awareness of pattern and the capacity for generalising. Arguing from this empirical data, we make two recommendations regarding choices in the early learning of number.

Key words: *early number learning; ordinality; number naming*  
Session type: *Research paper*  
Duration: *30 minutes*



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*Constructivist principles in mathematics lessons: Pi in the sky?*

Constructivist ideas about learning mathematics have existed at least since the second half of the 20th century, advocating learner sense-making through experience and discussion, and recognising the futility of lecturing and drill for long term understanding and retention; and governments and educational institutions internationally have endorsed these ideas (e.g. NCTM, 2014; Sutton Trust, 2014). Yet teaching in many cases remains transmissive and exam-focused (Ofsted, 2012) and results in students resisting further compulsory study after 16 (Noyes & Adkins, 2016). This presentation reports on the results of a survey of over 500 sixth formers regarding their experiences of school mathematics teaching across ten constructivist principles, and compares their experiences in mathematics with experiences in science, ICT and English. An analysis of averages indicated that talk was encouraged in the classroom and that different strategies were embraced, but that lessons were strongly focused on textbook learning – much more so than in the other subjects. Focus on strongly held beliefs revealed that mathematics received the fewest high scores across each of the constructivist principles, and was a close second to science in receiving low scores.

Key words: *constructivist; teaching; learning*  
Session type: *Research paper*  
Duration: *30 minutes*

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*Mathematics resilience: What is known in the pre-tertiary mathematics education research and what we have found researching non-mathematics-specialist tertiary students*

In recent years, there has been a rise in the number of studies into mathematics resilience. These studies have found that students who are mathematically resilient are likely to persevere with their study of mathematics. Also, the research suggests that when coached, students can develop mathematically resilient strategies that they can draw upon to persist with their engagement with mathematics. In the UK, mathematics resilience research has focused on the learning of school mathematics or workplace numeracy. It is plausible to suppose that the findings of the research relating to school mathematics or workplace numeracy may be generalizable to tertiary mathematics. This paper describes a two-phase study that explored mathematical resilience amongst students studying economics or related studies. First, a cohort of first-year students completed a mathematical resilience scale which measured the extent to which the students are mathematically resilient. The relationship between mathematical resilience and students' achievement in their highest pre-tertiary mathematics qualification was also explored. Second, semi-structured interviews were conducted with a small number of first-year and second-year students to explore their experiences of learning mathematics and the strategies they use to persist with mathematics. Some preliminary findings of the study and implications for teaching practice are reported.

Key words: *mathematics resilience; school mathematics; workplace numeracy; tertiary mathematics*  
Session type: *Research paper*  
Duration: *30 minutes*



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*'Critical Mathematics Education (CME)' Working Group - including discussion on 'making pedagogical rationale explicit to mathematics learners'*

The CME Working Group (launched in November 2015) is open to all and aims to promote research that brings about positive social change through mathematics education. CME aims to identify and challenge ways in which mathematics is commonly used to maintain the status quo and reproduce inequities in society. It proposes an alternative and empowering conceptualisation of mathematics, which enables people to better understand their social, political and economic situations, and to advocate and bring about changes leading to a more just and equitable society. During the first half of the meeting, Pete Wright will lead a discussion, drawing on his recent experiences observing PGCE mathematics student teachers, and highlighting an apparent reluctance to share their pedagogical rationale with learners. Bernstein's notion of strong and weak 'framing' suggests that working-class children may be disadvantaged by open-ended approaches to learning mathematics. Does this mean that such pedagogical approaches should be avoided? Or should we continue to explore ways for student teachers to engage with these approaches whilst making their rationale more explicit to learners? During the second half of the meeting, we will discuss possible foci for future meetings and potential areas of research that resonate with the working group's aims.

Key words: *critical mathematics education; empowerment; equity; social justice*  
Session type: *Working group*  
Duration: *60 minutes*

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*Difficulties in teaching calculus concepts in undergraduate service courses: The notion of limit of a sequence*

It is commonly agreed that undergraduate students encounter difficulties in understanding the notion of the limit in calculus courses. Both the formal and informal approach do not convey a setting that bridges the intuition and mathematical rigour. In this work, we explore the formal and informal definition of the limit of a sequence existent in several calculus textbooks in light of the recent research in the literature. A study was conducted on a large group of first year undergraduate students in University College Dublin, the largest university in Ireland. The findings reveal students' difficulties in formalising their mathematical observations along with a reluctance to employ formal or informal definition of a limit of a sequence in their arguments.

Key words: *service courses; undergraduate calculus; limit of a sequence; formal and informal definition*  
Session type: *Research paper*  
Duration: *30 minutes*

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*Mathematics teacher educator noticing: A methodology for researching my own learning*

How can Enactivism frame a methodology for research based on the Discipline of Noticing? What constitutes data and how can I use this data to support the development of expertise as a mathematics teacher educator? My PhD research concerns how and what I am learning in becoming a mathematics teacher educator. In this session, I will be presenting my interpretation of Mason's (2002) four interconnected actions within the Discipline of Noticing as a methodological framework for my research, that is, what I notice as a Mathematics Teacher Educator working with groups of teachers. Enactivism is proposed as a theoretical underpinning for Noticing as Research as it can



account for the inextricable relationship and interdependency between experience, action and knowing which form the foundations of Noticing. As a method of research, I am using Noticing as a way of developing my expertise through the development of a part of myself which remains separate from the emotions of the moment. I would like to explore what constitutes data in such a study and how working with this data, in a way guided by the methodological framework, supports my learning as a mathematics teacher educator.

Key words: *Enactivism; Discipline of Noticing; mathematics teacher educator learning*  
Session type: *Research paper*  
Duration: *30 minutes*

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*The early take-up of Core Maths project: Emerging national findings*

England is an outlier when it comes to post-16 participation in mathematics (Hodgen et al. 2010). One potential policy solution to this problem is Core Mathematics (DfE, 2015), an important new post-16 level 3 mathematics qualification equivalent in 'size' to an AS level, but intended to be studied over two years. Core Maths (CM) has been taught in 'early adopter' institutions since 2014, with first examination in summer 2016. This talk will use national data to investigate the emerging nature of the early uptake and attainment in the qualification, including demographic analysis (e.g. by gender), the nature and geographical spread of the institutions teaching CM, and differences by specification. This work forms part of a wider mixed-methods project, The Early Take-up of Core Maths (ETCM), assessing the early success or otherwise of this important and innovative new course. ETCM is a large-scale three-year project (2017-2020) funded by the Nuffield Foundation, designed to provide clear policy and practical outcomes for government and other stakeholders that will enhance and secure the long-term presence of CM in the post-16 mathematics curriculum in England. The talk will also outline the main strands of this project.

Key words: *Core Mathematics; curriculum; post-16*  
Session type: *Research paper*  
Duration: *30 minutes*

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*Algorithms ... Alcatraz: Are children prisoners of process?*

Multiplicative thinking is a critical component of mathematics which largely determines the extent to which people develop mathematical understanding beyond middle primary years. We contend that a major issue is the extent to which algorithms are taught without the necessary explicit connections to key mathematical ideas. This paper explores the extent to which some primary students demonstrate an understanding of the underpinning ideas and how they relate to the traditional written algorithm for multiplication. We examine the extent to which the students use the algorithm as a preferred choice of method. Indeed, we suggest that most students in the sample are 'prisoners to procedures and processes' whether or not they understand the mathematics behind the algorithms.

Key words: *multiplicative thinking; conceptual links; upper Key Stage 2*  
Session type: *Research paper*  
Duration: *30 minutes*



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*'Explanatory' talk in mathematics*

Explanations seem fundamental to teaching mathematics. One way of characterising teaching is to suggest that the job of a teacher is to explain mathematical ideas to their students. And yet some philosophers deny that mathematical explanations exist. This apparently radical position is the result of the observation that mathematical concepts seem not to be causally connected to each other; because of this, traditional philosophical accounts of explanation seem not to work in mathematical contexts. Our goal in this presentation is to report an empirical study that investigated the extent to which explanation is a feature of mathematics compared to other scientific disciplines. We explored the ways in which mathematicians and physicists talk about explanation (and related concepts) in their research papers. We found that mathematicians do not frequently use this family of words and that their use is considerably more prevalent in physics papers than in mathematics papers. In particular, we found that physicists talk about explaining why disproportionately more often than mathematicians. We discuss some possible accounts for these differences.

Key words: *explanation; proof; practice*  
Session type: *Research paper*  
Duration: *30 minutes*

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*Words and contexts: Teaching mathematics vocabulary*

Research into vocabulary learning emphasises the need to teach vocabulary in authentic contexts and through making connections to students' prior knowledge or experiences. In mathematics, we have vocabulary that is also widely used in everyday situations or in other school subjects with a similar meaning but we also have words which are used in everyday situations that have very different meanings. Finally, there are also words that students are unlikely to meet anywhere except in their mathematics lessons. In this session, we explore what might be meant by an authentic context in mathematics for these different types of words, and how these contexts may, or may not, support students in making connections.

Key words: *vocabulary; contexts; tasks*  
Session type: *Research workshop*  
Duration: *30 minutes*

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*Between the framework and the classroom: Designing a tool for curriculum development in mathematics*

Cambridge Mathematics is creating a framework for mathematics learning that is intended to support greater coherence, flexibility, and transparency in curriculum development, with the goal of increasing the accessibility of a good education in mathematics for every learner. We are building out this framework in the form of a toolset that can be used by curriculum developers to aid decision-making around scope, sequencing, activity design and professional development according to their own sets of priorities and constraints. In the design of this toolset, we aim to express the connected nature of mathematical understanding with respect to the evidence we are able to incorporate, while remaining flexible enough to change based on changes to that evidence base, whether from



feedback, additional review, new relevant empirical research, or direct evidence from implementation. This paper discusses work in progress on the development of the framework with respect to design methodology, through which we aim to create and maintain meaningful links between the theory and evidence informing our design choices, and feedback on the implementation of our design principles. In particular, we will explore the question *'Do the goals of the framework and the goals of the tool support or interfere with each other?'*

Key words: *curriculum; design; framework; mathematics*  
Session type: *Research paper*  
Duration: *30 minutes*

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*The FaSMEd project in South Africa: A design research project*

The Formative Assessment in Science and Mathematics Education (FaSMEd) project was a design research project funded by the EU between 2014 and 2016, with eight partners in Europe and one in South Africa. This presentation reports on the work of the South African partner. In South Africa, carefully designed lessons, mostly taken from the Mathematics Assessment Project and developed under the leadership of the late Malcolm Swan, were used in authentic classrooms. Researchers and teachers collaborated, over three rounds of interventions, to iteratively refine the lessons for the South African context, drawing on the emerging findings from trials in the classroom. The presentation discusses the key design decisions made by the teachers and researchers and reports on how the decisions were implemented in the classroom. It concludes with discussions about the inevitable tensions that arise in the design and re-design of resources to be used in the classroom, and pays a small tribute to one of the great designers of our times, Malcolm Swan. Video footage is used to provide the audience with a sense of the context, and to illustrate some of the classroom implementation, and gives a glimpse into a range of South African (Western Cape) classrooms.

Key words: *design research; formative assessment; mathematics; resources*  
Session type: *Research paper*  
Duration: *60 minutes*

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*Sharing chocolate: Year 8 students' use of narrative, visual and symbolic representations of fractions*

In this presentation, we discuss incidents from video recordings of a lesson and follow-up interview arising from a story about 'sharing chocolate'. The students, from a relatively 'low attaining' Year 8 (Grade 7) class, made use of various representations of fractions. However, while they might sometimes have made good sense of a representation by linking it to the story, they often seemed not to make fruitful connections between representations. Further, representations were often used procedurally in ways that fitted what students remembered or thought they'd remembered about 'fractions', rather than by how the procedures and outcomes might have related to the story.

Key words: *fractions; representations; links*  
Session type: *Research paper*  
Duration: *30 minutes*



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*Investigating the linguistic conventions of proof writing in university mathematics*

We studied the linguistic conventions of mathematical proof writing at the university level by asking mathematicians and university students to read seven partial proofs based on student-generated work and to identify and discuss uses of mathematical language that were out of the ordinary with respect to what they considered standard mathematical proof writing. Data from a survey of 128 mathematicians are also used to discuss the extent to which a larger sample of mathematicians agree with regard to these linguistic conventions of mathematical proof writing. Results indicate that correct grammar is necessary in proof writing, but that the extent to which mathematicians view these breaches of convention as unconventional may depend on the context of the proof. In particular, these data point to a lack of agreement among mathematicians on the linguistic expectations of the proofs written by their students.

Key words: *mathematical proof; mathematical language; university students; mathematicians*  
Session type: *Research paper*  
Duration: *30 minutes*

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*Teachers' perception of mathematical tasks: What secondary mathematics teachers 'saw' in a published task, and how this changed following enactment*

What do teachers perceive when presented with a mathematical task? In a dissertation study for the University of Oxford MSc in Teacher Education (Mathematics), I worked with three teachers to investigate this research question. Teachers' submitted written planning notes and subsequent interview responses were analysed to identify lesson images representing their intended use of a published task, before and after observing teaching using the same task. Each teacher had a distinct plan for how they intended to use the same task, and each responded differently following enactment of the task. The difference in intended use reflected variation in how the task was perceived, and in how teachers' beliefs, knowledge and goals informed pedagogical decision making. Teachers adapted the task better to align with their own beliefs, knowledge and goals, but the design of the task also allowed and constrained teachers' decisions. Teachers formed a relationship with this particular task, which they either developed, challenged or acquiesced to, based on their differing perception of the task. Some teachers' experience of enactments of the task – observation of another teacher's lesson, and teaching their own lesson (two of the three teachers) – led to changes in teachers' goals as reflected in their revised plans.

Key words: *teacher education; instructional resources; teacher beliefs*  
Session type: *Research paper*  
Duration: *30 minutes*

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*Developing calculation fluency: How do pupils check their work?*

This paper focuses on the approaches favoured by Year 6 pupils when checking their written calculations. The existing literature tends to focus on the strategies chosen by pupils, rather than exploring the reasons behind their decision-making. This paper forms part of my mixed methods doctoral thesis which addresses gender differences



in calculation fluency. The overall sample consisted of almost 700 pupils spread across 19 schools, and this paper draws on individual interviews with 23 of those pupils. It explores how they checked their answers for 16 multi-digit, age-related calculations addressing addition, subtraction, multiplication and division. The findings revealed when pupils checked their answers, how they checked them and whether there were any gender differences in their approaches. Although it is a small sample study, mathematics educators should be able to relate the findings to their own experiences and settings.

Key words: *calculation; decision-making; curriculum; fluency; checking*  
Session type: *Research paper*  
Duration: *30 minutes*

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#### *School students' experience of studying AS and A-level Further Mathematics via a blended learning option*

A qualitative study was carried out by the authors into the students' experiences of studying AS and A-level Further Mathematics via a mixture of live online sessions and face-to-face support offered by the Further Mathematics Support Programme Wales. The study found out that although the FMSP students felt generally positive about both online components of their course and the course as a whole, the FMSP model clearly expected a lot from the students in terms of motivation and organisational skills. The study suggests a range of improvements that can be adapted by the FMSP but also demonstrates that the home institutions could do a lot and are well-placed to contribute to an improved FMSP learning environment. We argue that the FMSP model further contributes to narrowing the "pipeline" of the Further Mathematics students. Thus studying the subject as a fully time-tabled option should remain a preferred choice. There is currently little research into how the experiences of predominantly school-based students of online components of their course contribute to their experience of the course as a whole. The present study enables us to envisage problems that may arise in any A-level subject offered through a blended learning model.

Key words: *Further Mathematics; blended learning; student choice*  
Session type: *Research paper*  
Duration: *30 minutes*

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#### *Mathematics education and the General Election result*

BSRLM falls on the day after we get the results of the UK's snap General Election. The two main political parties have presented us with contrasting policies on education, Brexit, the economy and other areas which affect our work. These represent radically different visions for the country. Policies are not totalising. But it does shape what is possible for teachers, students and academics, in the present and beyond. In this session, I will offer some reflections on the implications of the election results for mathematics education, in order to open up a discussion about what we do next.

Key words: *policy, politics, government, General Election, socialism*  
Session type: *Research workshop*  
Duration: *30 minutes*



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*Examining prospective mathematics teachers' pedagogical content knowledge of limit and continuity using vignettes*

The aim of this study is to examine upper secondary prospective mathematics teachers' pedagogical content knowledge (PCK) with regard to difficulties with and misconceptions about the concepts of limit and continuity. Participants are twenty-five prospective teachers who are enrolled in a teacher preparation program in a state university in Turkey. Participants' PCK were explored using vignettes which illustrate difficulties and misconceptions as reported in the related literature. Scenarios in vignettes include students' answers and solutions, and teachers' responses to students' answers. Data were analysed using content analysis which were based on Jacobs, Lamb and Philipp's (2010) framework on noticing. In the light of this framework, the findings will be discussed with regard to how participants (a) notice students' difficulties and misconceptions, (b) interpret them, and (c) decide on overcoming these difficulties.

Key words: *pedagogical content knowledge; limit; continuity; vignette; prospective mathematics teachers*  
Session type: *Research paper*  
Duration: *30 minutes*

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*The process of reconceptualising lesson observation for the development of reflective practice*

Lesson observation and the post-lesson discussion (PLD) is a common aspect of beginning teacher education. In many cases, the PLD is a transmission of judgemental information from the observer to the teacher and the opportunity for reflective development is overlooked. This presentation examines the somewhat limited opportunities for beginning teachers to develop 'reflection-on-action' and explores how Heron's (1976) six category intervention analysis can be utilised to develop the use of lesson observation as a tool for reflection. Fifty-two in-school mentors and 24 beginning teachers participated in a semester-long research project involving workshops on the practice of lesson observation and post-lesson discussion through the lens of Heron's six categories. Some of the findings from the research will be presented.

Key words: *initial teacher education; mentor development; observation; post-lesson discussion*  
Session type: *Research paper*  
Duration: *30 minutes*

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*Division: Exploring formal methods from the perspectives of primary children and trainee teachers*

After years of frustration, believing there might be better ways of using resources to support children's understanding of formal methods for division, a conversation with a primary PGCE student prompted action! This session will explore one approach to the use of place value resources (trials in school) and then our research into supporting trainee teachers in their quest to understand what can traditionally be seen as a tricky topic. Literature suggested that providing pre-teaching, using a 'flipped classroom' approach, might be beneficial and initial findings suggest this to be the case.



Key words: *division; formal written methods; primary; initial teacher education*  
Session type: *Research paper*  
Duration: *60 minutes*

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*'History of Mathematics' Working Group - A cultural history of the Pythagorean Theorem: Opportunities for the curriculum*

As a standard part of the school mathematics curriculum, the 'Pythagorean Theorem' is presented to students 'algebraically' or 'geometrically', rarely with any particular motivation or context. In this workshop, we will offer some insights into the long and varied history of the 'Pythagorean relation'. We will explore its origins, development, and the meaning of its current status as a 'theorem' in mathematics. We will discuss the opportunities for the mathematics curriculum and implications for the classroom.

Key words: *mathematics curriculum; Pythagoras' theorem; history of mathematics in education*  
Session type: *Working group*  
Duration: *60 minutes*

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*All aboard: Studying the link between classroom dialogue and the implementation of rich tasks in post-16 mathematics with Underground Mathematics*

Underground Mathematics (UM), formerly the Cambridge Mathematics Education Project, develops online resources to support teaching and learning for post-compulsory mathematics (students aged 16-18). UM strongly believes that dialogue is inherent to mathematics. To fully understand the implementation and use of new curricular resources, UM believes an investigation of classroom dialogue is essential. The research employed a mixed-method multiple-case study approach and was designed to answer the following questions: *How is UM implemented in post-16 classrooms?; How is attention to dialogue essential in understanding UM implementation?* In this session, we share insights from our data analysis, which focused on identifying attributes of implementation of the rich tasks across classrooms, paying special attention to dialogue (including both teacher-student and student-student talk). The research uses the Cam-UNAM Scheme for Educational Dialogue Analysis (SEDA), a tool developed by researchers in the UK, Spain, and Mexico, to analyse dialogic interactions, in order to categorise the types of dialogue students and teachers employ in mathematics classrooms influenced by UM. Through our study, we aim to present a methodology that positions classroom dialogue as central to the investigation of mathematics teaching and learning.

Key words: *classroom dialogue; evaluation; post-16 mathematics; instructional resources; case study research*  
Session type: *Research paper*  
Duration: *30 minutes*



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*Completing the square: The cultural arbitrary of Oxbridge entrance preparation?*

I report on part of a research project which investigated how independent schools might give their students an advantage when they apply to elite universities. The case study approach draws on qualitative methods and examines a preparation programme, in an independent school, for students applying to study mathematics at elite universities. I draw on a Bourdieusian conceptual framework to analyse teachers' social and cultural capital and show how this can provide experiences that are thought to confer distinction. As an insider researcher and mathematics teacher on the programme, I was able to examine my mathematics sessions in detail. Here I look at some of the skills which I think could be argued to become arbitrary, rather than functional, in practice and to what extent a student who acquires these skills gets 'use' and/or 'exchange' value from these skills.

Key words: *capital; Bourdieu; elite universities; independent schools; advantage; post-16 education*  
Session type: *Research paper*  
Duration: *30 minutes*

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*Developing a concrete-pictorial-abstract model for negative number arithmetic*

Research findings and assessment results persistently identify negative number arithmetic as a topic which poses challenges to learners. As a foundational topic in mathematics, secure conceptual understanding and procedural fluency in negative number arithmetic are essential to other areas of mathematics such as algebra. This study aims to build on existing research which identifies four conceptualisations involved in negative number arithmetic: unary, binary, and symmetric operations, and magnitude, to develop a concrete-pictorial-abstract (CPA) model which uses the vertical number line and 'number bar' manipulatives as the key representations. A trial group ( $n = 7$ ) of UK secondary school students taught using a CPA model, are found to have made significantly greater increases in post-assessment scores ( $p = 0.025 < 0.05$ ), compared to a control group ( $n = 5$ ) who were taught using a non-CPA approach. Analysis of results reveals that the trial group made significant increases in addition ( $p = 0.034 < 0.05$ ) and subtraction ( $p = 0.040 < 0.05$ ) with negative numbers in particular. The results suggest that a CPA model, using the number line as the key representation, may support students' conceptual understanding of negative number arithmetic more effectively than a conventional non-CPA approach.

Key words: *negative number arithmetic; concrete-pictorial-abstract; instructional manipulatives; secondary*  
Session type: *Research workshop*  
Duration: *30 minutes*

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*Mathematics mastery: From subject leads' perspective*

This session presents research about teachers' views of the notion of 'Mastery' in Mathematics. Mastery approaches are gaining a strong foothold in UK schools, having been promoted as a key reason for the apparent success of some countries in international comparisons. However, the definition of 'mastery' is not universally agreed in the research literature, policy documents or curriculum materials. The research we are embarking on explores the dimensions within teachers' views of mastery. It is based on semi-structured interviews of eight subject leads at state schools in North Eastern England. Initial analysis of the interviews identified a number of



key areas which the teachers talked about: the definition of mastery, the conditions of mastery, the consequence of mastery, and contrasts with conventional teaching. The consensus from the interviews suggests that a mastery approach can deliver significant gains in conceptual understanding and pupil engagement. However, there are striking differences across the interviews in what mastery means. For example, we found widely differing views about the role of misconception in a mastery classroom. The session will present some of the background to the differing notions of mastery, outline the research we are undertaking and present some of the initial findings for discussion.

Key words: *mastery teaching, misconception, understanding*  
Session type: *Research paper*  
Duration: *30 minutes*

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*Authoring oneself as a teacher of mathematics: Interpretations of the symbolic figure of 'The Good Mathematics Teacher'*

In this presentation, I will share my doctoral research on the identity work done by teachers in Year 6 classrooms. Adopting Holland et al.'s (1998) idea of 'symbolic figures', I have found that my participating teachers talk – sometimes explicitly – about themselves and others in relation to three 'symbolic figures': The Good Teacher, The Good Mathematics Teacher and The Year 6 Teacher. In this presentation, I will share interview data and propose some different interpretations of the symbolic figure of The Good Mathematics Teacher. I will invite discussion about other ways of imagining this figure.

Key words: *teacher identity; self authoring; symbolic figures*  
Session type: *Research paper*  
Duration: *30 minutes*

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*Where are the girls and women in mathematics-focused picturebooks? Preliminary pilot findings*

While the effectiveness of using children's literature to support the development of children's mathematical understanding has already been explored, virtually no studies have been conducted to examine the representation of girls and women in such literature, particularly in relation to picturebooks with a mathematical focus. Such examination is imperative, particularly when a recent study of over 5,000 non-mathematics picture books found that male characters are represented nearly twice as often in titles and 1.6 times as often as central characters, highlighting the existing symbolic annihilation where female characters are either under-represented or not represented at all. In the context of mathematics, this is concerning, particularly when it has been found that young girls are more likely than their male counterparts to experience anxiety and have lower perceived competence level in mathematics. Whilst gender representation in children's literature has been extensively researched, the focus of those studies is not on picturebooks that are used for mathematics instruction. Subsequently, the overall objective of this study is to systematically capture gender representation in mathematics-focused picturebooks. This presentation will report some preliminary findings of the pilot phase of the study.

Key words: *mathematics picturebooks; gender representation; symbolic annihilation; coding*  
Session type: *Research paper*  
Duration: *30 minutes*



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*A case study to explore approaches that help teachers engage with students' development of mathematical connections*

It is accepted that pupils understanding of mathematics can be developed by exploring connections between concepts and different representations (ACME 2011; Askew, 1997; Swan, 2005). However, there is a shortage of mathematics specialists and many reports (ACME, 2002; Cockroft, 1982; Smith, 2004) contend that one of the most effective ways to raise the quality of mathematical provision is to expand CPD for teachers of mathematics. This research study considers the Collaborative Connected Classroom (CCC) model (Trubridge & Graham, 2013) and how it might be implemented within a school via a programme of sustained CPD that incorporates; research sharing, engagement with activities that bridge theory to practice, and then active collaboration and exploration of ideas. This session reports the findings so far when looking at which aspects of the CCC model engaged teachers themselves and then how they used these tasks with their learners to develop mathematical connections.

Key words: *CPD; connections; conceptual understanding; secondary teachers*  
Session type: *Research paper*  
Duration: *60 minutes*

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*Mathematics teaching in China: Recent developments in curriculum design, assessment and teaching methodology*

The papers in this session introduce current developments in mathematics education in China, focusing on curriculum development, assessment and the introduction of new teaching methodologies. The individual papers are:

- An introduction to the teaching syllabus or curriculum standards of elementary mathematics in China (Jian Zhang)
- Heuristic teaching in math for primary and secondary schools (Chun Cai)
- Assessment methods in mathematics courses in Chinese primary and secondary schools (Pei Wang)

Key words: *curriculum development; assessment; teaching method*  
Session type: *Research paper*  
Duration: *60 minutes*