

BSRLM Conference Abstracts
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Prospective mathematics teachers' views on pedagogical affordances of Geogebra for understanding geometry theorems

This paper explores prospective mathematics teachers' views on pedagogical affordances of using technology for understanding Geometry at upper secondary level. The study was situated within a four-year teacher preparation program in Turkey. Participants are fifteen prospective mathematics teachers who were enrolled in an elective course which focused on the use of Geogebra. Prospective teachers worked in groups of two's and three's. Each group was asked to select and investigate two Geometry theorems one of which is beyond the national curriculum. They prepared a report which reflected on the pedagogical affordances of investigating Geometry theorems and their proofs in Geogebra environment. Data obtained from the reports and Geogebra files were analysed using content analysis. Data analysis indicated that prospective teachers mostly reported on pedagogical affordances such as investigating various cases to make generalisations, providing feedback and producing multiple representations. Different themes emerged for the theorems which were beyond the curriculum such as providing open-ended problems and creating investigative processes for students.

Key words: *prospective mathematics teachers; technology-enhanced environments; Geometry Theorems; Geogebra; pedagogical affordances*
Session type: *Research paper*
Duration: *30 minutes*

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Developing a primary scheme of work based on free resources

This session will relay a research and development project carried out in a primary school in Brighton over the last three academic years. The impetus for the project was the desire to develop an approach to teaching mathematics that focused on motivation and engagement and made use of a range of free resources with which the project leader was familiar. It has used a coaching approach to teacher development alongside the design of a programme of study that is compliant with the current national curriculum but emphasises an holistic approach to mathematics, mathematical reasoning, problem solving and fluency. Discussion will focus on how the small scale findings of this project might be developed with more schools.

Key words: *primary; curriculum design; teacher development*
Session type: *Research workshop*
Duration: *30 minutes*

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Training mental rotation skills to improve spatial ability

Prior research indicates that spatial skills, for example in the form of Mental Rotation Skills (MRS), are a strong predictor for mathematics achievement. Nevertheless, findings are mixed whether this is more the case for other

spatial tasks or, as others have stated, numerical and arithmetical performance. In addition, other studies have shown that MRS can be trained and that they are a good predictor of another spatial skill: route learning and wayfinding skills. This paper presentation explores these assumptions and reports of an experiment with 43 undergraduate psychology students from a Russell Group university in the south of England. Participants were randomly assigned to two conditions. Both groups made pre- and post-tests on wayfinding in a maze. In-between the intervention group trained with an MRS tool the first author designed in the MC-squared platform, which was based on a standardized MRS task (Ganis & Kievit, 2015). The control group did filler tasks by completing crossword puzzles. Collectively, the 43 students made $43 \times 48 = 2064$ assessment items for MRS, and $2 \times 43 = 86$ mazes. Although the treatment group showed a decrease in time needed to do the maze task, while the control group saw an increase, these changes were not significant. Limitations are discussed.

Key words: *mental rotation skills; spatial skills; digital tool*
Session type: *Research paper*
Duration: *30 minutes*

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Calculation strategies for Year 5 Children: 10 years on

For 10 years, we have collected examples of how Year 5 children solve calculation questions. We have examined the range of strategies used and considered the success of each strategy. This paper continues this research with a sixth data set. Like the previous research, we collate the proportions of children who are successful and explore the strategies employed and we will look at examples of these in the session. However, this study also examines a small group of children from one particular class to consider how successful they are across the four calculation strategies. There will be an opportunity to look at a few examples of how children have answered all four questions and discuss what teaching and learning has potentially taken place. Finally, we will focus on a range of answers offered for the division question from a different school and ask what understanding about division is demonstrated.

Key words: *calculations; standard algorithm; conceptual understanding; Year 5; strategies*
Session type: *Research paper*
Duration: *60 minutes*

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Describing mathematics teaching practices involving pupil use of dynamic technologies: snapshots of effective practices

The Nuffield-funded 'Cornerstone Maths' Project in London provides the context for this research workshop, in which we are researching the nature of teacher's mathematical knowledge for teaching (MKT) and associated mathematical pedagogic practice (MPP) as they develop their use of dynamic maths technology in Key stage 3 lessons. Whilst our earlier BSRLM research presentations have focused on aspects of teachers' MKT, this session reports methodologies and findings concerning teachers' practices with technology, with particular emphasis on mathematical representations, structures and explanations. In the workshop, we will share video data and invite participants to discuss and critique our analyses, which we are anticipating will support us to highlight aspects of teachers' practices that seem to be more effective with respect to the design principles of the Cornerstone Maths innovation.

Key words: *classroom practice; dynamic technology; professional learning*
Session type: *Research workshop*
Duration: *60 minutes*

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Building and sustaining active research collaborations with teachers of mathematics

This BSRLM working group is convening for a third time to explore collaborations between teacher and researchers in the processes of doing, reflecting upon and engaging with the findings, of mathematics education research. At our last meeting, we agreed we would maintain the on-going discussion that concerns the opportunities for researchers to collaborate with teachers and schools as active participants in research studies and associated methodologies. For regular participants we invite you to bring draft texts that report outcomes of research studies in the form of BLOG entries and other forms of communications for constructive critique and refinements by participants during the session.

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

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'Concrete to Pictorial to Abstract' and other myths and rites of learning mathematics

In this session, Alf will draw on recent research in primary schools to call into question the dominant narrative of 'development' and 'trajectories' in learning mathematics. Such a narrative is seen, for example, in the assumption that children must move from the concrete to the pictorial to the abstract. The session will set out philosophical, practical and empirical reasons to question this assumption; and, since our own classroom practice inevitably embodies myths and rites about learning mathematics, to consider alternatives. One alternative myth that will be drawn out and exemplified is that learning number can become fast and engaging if the concrete, the pictorial and the abstract are all around all the time.

Key words: *learning mathematics; child development; abstraction*
Session type: *Research paper*
Duration: *30 minutes*

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Mathematics, motor skills, mindset and madness workshop

Interactive session looking at links between mathematical skills and motor skills; how mathematical skills can be improved by improving motor skills. That not understanding the link between physiology and learning can put excessive pressure on to children.

Key words: *learning; basic cognitive skills; primary and struggling secondary learners*
Session type: *Research workshop*
Duration: *60 minutes*

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Designing creative electronic books for mathematical creativity

There is potential and great value in developing digital resources, such as electronic books, and investigating their impact on mathematical learning. Our focus is on electronic book resources, which we refer to as c-books, and are extended electronic books that include dynamic widgets and an authorable data analytics engine. They have been designed and developed as part of the M C Squared project (www.mc2-project.eu/), which focuses on social creativity in the design of digital media intended to enhance creativity in mathematical thinking (CMT). Researchers collaborating with mathematics educators and school teachers form Communities of Interest and Practice (COI and COP) that work together to creatively think and design c-book resources reflecting current pedagogy for CMT in schools. We plan to present a number of these books and discuss how they were designed. We will share our reflections from using one of the c-books for a school study and highlight its impact on students' learning, but also how c-books could be integrated in the mathematics classroom.

Key words: *electronic (c)-books; creative mathematical thinking; design of digital resources*
Session type: *Research paper*
Duration: *60 minutes*

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Making Numbers: implications and further development

We will share the final report on the Nuffield Funded project, 'Using Manipulatives in the Foundations of Arithmetic' and explore some of the issues as well as possibilities for further research. We will discuss our main themes of counting, comparison and composition as central in supporting teachers' development of children's understanding of arithmetic. We will consider the need to develop awareness of pattern and structure as well as children's explanations and recordings. How can a project like ours move from dissemination to impact?

Key words: *arithmetic; manipulatives; teacher development; primary*
Session type: *Research workshop*
Duration: *60 minutes*

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Exploring prospective mathematics teachers' professional identities through Communities of Practice framework: post-Lesson reflection report technique

The aim of this study is to investigate prospective mathematics teachers' professional identities by analysing their post-lesson reflection reports. The study was conducted in a teacher preparation program in a state university in Istanbul, Turkey. Participants of the study are twenty one upper secondary prospective teachers who taught a total of forty five lessons in two partnership schools. Data source of this study is thirty three post lesson reflection reports. They were analysed using content and descriptive analysis. Data analysis was based on three constructs of communities of practice framework: engagement, imagination and alignment. The findings of the study indicated that three constructs were explanatory for revealing prospective teachers' teaching approaches. The study also indicated that post lesson reflection reports was found to be an effective tool for exploring professional identity.

Key words: *prospective mathematics teachers; school practicum; professional identity; Communities of Framework*
Session type: *Research paper*
Duration: *30 minutes*

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Some teaching/learning insights that need to be researched

There is, unavoidably, a gap between teachers of mathematics, and researchers into mathematics education. Experienced teachers often have personal 'tricks', for helping their students learn mathematics, but these are usually based on intuition, and not based on evidence - because it is so difficult to get hard evidence. Nonetheless, it should be possible to investigate with some degree of rigour, some of the 'small' teaching methods which some teachers have found especially effective. These are not the 'macro issues', such as investigation vs direct instruction, collaboration vs individual work, the effect of class size, whether new technology is helpful, or 'teacher effect'. Rather they are questions like the best way to introduce students to trigonometry, ways to remember particular important algebraic identities, how to ease the learning of number sequences, and so on. This workshop will put forward a number of these 'micro issues', and discuss ways that research programmes might be created to investigate their effectiveness.

Key words: *visualisation; cognitive load; priming; proficiency*
Session type: *Research workshop*
Duration: *30 minutes*

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Making choices when solving quadratic equations

There are three common algebraic methods for solving quadratic equations in U.K. Classrooms: factorising; completing the square; and using the quadratic formula. However research shows that internationally students tend to choose to use the quadratic formula, even when the quadratic equation is given in factorised form. In this session we explore the decisions student teachers make when solving quadratic equations using 3 tasks. We focus in particular on how the form of the equation and the nature of the roots affects these choices

Key words: *quadratic equations; student teachers; tasks*
Session type: *Research paper*
Duration: *30 minutes*

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Interpretation and production of diagrams when tackling proof problems in a dynamic geometry environment

Dynamic geometry environments (DGEs) can help enrich students' proof-related activity by, for example, enabling students to access a variety of diagrams when making conjectures and discovering counterexamples. Previous studies regarding the use of DGEs have analysed student activity in terms of dragging modalities, such as how students drag points to transform diagrams. In this presentation, we focus on another aspect, namely students' interpretation of diagrams. Using the distinction between 'object-oriented' interpretation and 'relation-oriented' interpretation from the literature, we analyse data from a task-based interview with a triad of secondary school students (aged 16–17 years old) conducted in our research project addressing task design for facilitating student

activity of proofs and refutations. We show that the notion of relation-oriented interpretation might be useful for understanding the way students tackling proof problems use a DGE to produce diagrams, some of which are counterexamples to their conjecture.

Key words: *dynamic geometry environment; geometric diagram; proof; secondary school*
Session type: *Research paper*
Duration: *30 minutes*

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Understanding the array as a model of multiplication

The rectangular array is widely regarded as a key model for developing an understanding of multiplication. It can provide insight into the structure of multiplication and make visible its commutative and distributive properties. Also, as the array evolves into the area model, it can aid the shift from multiplication with whole numbers to multiplication with rationals. However, research literature on primary school children suggest that getting to grips with the structure of the array is far from trivial. Our work with secondary school students suggest that we tend to underestimate these difficulties and move on from the array too quickly. In this session, we discuss two interviews with Year 7 students (age 12+) in which we asked them to explain why one can use multiplication to evaluate an array. We also look briefly at methods Year 8 students used to find the area of a rectangle with rational number dimensions.

Key words: *array; multiplication; model; understanding*
Session type: *Research paper*
Duration: *30 minutes*

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Digital manipulatives for early number learning: Numbuko

Since Fröbel presented his 'gifts' almost 200 years ago, educators have been designing physical learning materials ('manipulatives') to help children learn. From Cuisenaire's rods to Dienes' Blocks, we have created numerical representations aiming to help children explore, interpret, and communicate mathematical ideas. Digital technology has enabled new representational forms: screen-based 'virtual manipulatives' that can change shape, size or colour, or double/disappear at the touch of a button. More recently we have seen digitally augmented physical designs ('digital manipulatives') claiming to unite the representational benefits of digital technology and physicality. This talk will discuss the potential of digital manipulatives to create novel and more powerful forms of numerical representations for children's mathematical learning, using a particular example, Numbuko (www.numbuko.com), to ground discussions. Numbuko has been realised through a University of Edinburgh spin-out company 'PlayTalkLearn' and consists of blocks that attach magnetically in any direction but change colour according to the specific number attached linearly: described as a 'decomposable form of Cuisenaire rod'. Numbuko's intention is to make pre-school mathematics playful; however, the design offers a focus for debate around why and how we should represent number, and the opportunities and challenges for designers seeking to create effective new materials.

Key words: *manipulatives; technology; representations; design*
Session type: *Research workshop*
Duration: *60 minutes*

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Mathematics and fictions of the post-2008 financial crisis

Mathematical instruments were at the heart of the 2008 financial crash. Yet, what are the stories we tell about the place, power and potential of mathematics through this crisis? To answer this question I analyse four financial-crisis fictions: the films *Margin Call* and *The Big Short*, and the novels *Kapitoil* and *Capital*. I will show that these fictions offer tentative critiques of the objectivity and elitism of mathematics that we can use to open up different mathematical possibilities. This is a dry run of a keynote paper I'll be presenting at Mathematics Education and Society in 2017.

Key words: *popular culture; financial crisis; democracy; masculinity; poststructuralism*
Session type: *Research paper*
Duration: *60 minutes*

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Primary teachers' responses to three key policy phases

The three key policy phases relevant to my study are the launch of the Primary National Strategy (PNS) in 2006, the removal of the PNS in 2011 and the introduction of a new National Curriculum (NC) in 2013. Although the PNS was a non-statutory document, teachers were subjected to accountability and performativity mechanisms that tested their adherence to it, which Fink (2001) refers to as policy compliance. According to Foucault (1982) individuals become subjects of a power relationship, controlled by an external party. A teacher's sense of professional agency will affect the extent to which policy directives have an impact (Day, Sammons, Stobart, Kington & Gu, 2007). Individuals can exert teacher agency, which according to Kelchtermans (2009) incorporates emotional responses and a sense of self. Head teachers, mathematics coordinators and teachers have been asked to recall their perceptions of factors that influenced their policy enactment of the PNS and new NC. Their responses will be analysed through the theoretical lens of power, policy as a process and teacher agency as I explore the landscape in which teachers enacted these nationally reforming policy documents.

Key words: *PNS; teacher agency; power*
Session type: *Research paper*
Duration: *30 minutes*

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Exploring calculus through its history: reflections on some fundamental concepts

The new A levels in mathematics will be assessed at the end of a two-year course, providing the opportunity to revise schemes of work that develop mathematical understanding alongside technical competence. The calculus has a fascinating and turbulent history and reflection on some of its discoveries could inform some exciting approaches for the modern classroom. In this workshop, we will exemplify and develop ideas for exploring aspects of differentiation following approaches to integration from Cauchy introduced by Danish colleagues at the recent Anglo-Danish teachers' conference.

Key words: *calculus; derivative; limit; function*
Session type: *Working group*
Duration: *60 minutes*

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Exploiting programming to explore mathematics: a snapshot of the potential and challenge

This research workshop will share the background, aims and methodology of the ScratchMaths project* (2014-17), design research that has resulted in materials (for students aged 9-11 years) and professional development to support the development of computational skills and mathematical reasoning through learning to program in Scratch. First, we will present findings that show how we set out to exploit the computational concept of broadcasting (the way that objects communicate) as a basis for exploring place value. Second, we throw light on how far pupils of this age are able to interpret and evaluate different algorithms that solve the same problem. We end by discussing the potential and challenges of harnessing the opportunity of a compulsory computing curriculum for enhancing mathematical investigation. *We acknowledge with thanks the funding received from the Educational Endowment Fund. The project is being independently evaluated following a randomized control trial model involving over 100 primary schools across England.

Key words: *programming; Scratch; algorithm; place value*
Session type: *Research workshop*
Duration: *60 minutes*

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Understanding and overcoming number difficulties

An estimated 6% of children have severe specific arithmetic (number) learning difficulties, implying there is at least one in each class in mainstream primary schools (Dowker, 2004). However, the only agreed mathematical characteristic is a persistent difficulty in remembering number facts and causal theories range from a deficient neurological 'number module' to poor mathematics teaching (Gifford, 2006). Furthermore, there is currently little research and agreement across literature in understanding the characteristics of children with number difficulties (Thouless, 2014). In this session, the researchers will briefly outline their proposals for a project with primary schools that aims to: (i) analyse the characteristics of children who are identified as having number difficulties; (ii) analyse the unique number difficulties faced by individual children; and (iii) analyse the different perspectives about the nature of a child's number difficulties. The researchers will then work with participants in groups to help clarify key questions related to this project, including: how would you define a child with number difficulties; what does significantly below national expectations mean; and what key factors do you think should be considered in the study design at the onset of this project? The session will conclude with a summary of groups' discussions.

Key words: *number difficulties; characteristics; primary mathematics*
Session type: *Research workshop*
Duration: *30 minutes*

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Improving problem-solving skills in Mathematics

Since 2005, students in Years 7 to 10, and GCE students in the Sixth Form, at an independent school in London have sat the UKMT's Mathematics Challenges each year. Since 2013, the Year 11s have also been sitting the Intermediate Challenge. From 2012 various attempts have been made to prepare students for the Challenges,

both within and outside classroom time. These include classroom sessions devoted to solving Challenge questions, the timely provision of past papers and solutions for preparation before the Challenges, supporting the Primary School in entering selected 10 and 11 year-olds, supporting discretionary entries to the Olympiad, preparing video solutions to sets of Challenge questions and, more recently, preparing 'prompt' videos which are intended to activate the students own problem-solving powers rather than just providing solutions. The UKMT provides user-schools with a complete set of scores for each of the three Challenges every year, and this has built up into a good data set. In this session, evidence of students' improvement in problem solving will be presented in two forms: the number of awards of Bronze, Silver and Gold Certificates, and a study of the students' average scores in relation to the national averages. Some of the resources developed have the potential for wider dissemination and the speaker would like to discuss how they might best be assessed in formal or informal trials.

Key words: *problem-solving; supportive resources*
Session type: *Research paper*
Duration: *30 minutes*

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Social justice in the mathematics classroom: adopting a participatory action research methodology

This session will consider the findings from a research project based on collaboration between myself and five secondary mathematics teachers based in London schools (Wright, 2016). By planning, teaching, and evaluating a series of classroom activities, the research group demonstrated how making mathematics more relevant and meaningful can enhance students' engagement and agency. The collaborative and mutually supportive nature of the group developed teacher researchers' self-efficacy in addressing issues of social justice and empowerment in their mathematics classrooms. The project demonstrated the potential of the 'critical research' model of participatory action research (Skovsmose & Borba, 2004) for challenging assumptions and transforming classroom practice. Discussion will focus on the implications of the 'critical research' model for further study in this field.

Key words: *social justice; school mathematics; participatory action research*
Session type: *Research workshop*
Duration: *60 minutes*