

BSRLM Conference Abstracts
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Bangladeshi rural secondary school children's attitudes towards mathematics: Does it vary by gender?

It is recognized that an increasing number of students who are deciding not to study mathematics beyond minimum secondary school requirements and that many more girls than boys make this decision. A set of variables not only affects the amount of effort one is willing to employ to learn mathematics, but also influence on the election of additional mathematics course beyond the basic requirements. This paper reports the results of the analysis of pilot study data gained from a survey using the Fennema-Sherman Mathematics Attitude Scales (FSMAS) (Fennema & Sherman, 1976). The survey with 44 boys and 145 girls across three rural secondary schools in Bangladesh show that the overall mean attitude score of girls is higher than boys although boys are found slightly better confident in mathematics than girls. The girls of mixed schools and girls' only schools seem to have similar attitudes towards mathematics, but in the mixed schools, the boys' attitude score are found significantly less than the girls' score. Attitude score is remarkably lower for the children who do not study 'higher maths' optional course than those who study.

Age range: *Secondary education*
Key words: *attitude survey; FSMAS; gender difference; higher mathematics; rural secondary school*
Session type: *Research papers*
Duration: *30 minutes*

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Kelly's story: Transformative identity work in primary mathematics teacher education

This is a positive story of a student teacher's transformation from being scared of mathematics to recognising herself as a confident and competent mathematics teacher. This study presents this transition as a complex process involving supportive professional and social relationships, deep engagement in pedagogy, negotiation between conflicting discourses as well as oppressive peer relationships, regulation in practice settings, negative memories of school, absolutist discourses of mathematics and gendered performances. In addition, it is argued that experiencing contradictions, in both university and classroom settings, between authoritative and internally persuasive discourses, intensified transformative identity work.

Age range: *Teacher education*
Key words: *discourse; identity work; teacher education*
Session type: *Research papers*
Duration: *30 minutes*

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Mathematics teachers working on pauses

In this session, we look at what happened when a group of mathematics teachers in one school chose to work on using pauses and silences within their whole class teaching. This is one of a number of approaches the teachers

are exploring with us in order to encourage students to contribute and develop how they listen to each other and discuss mathematics. The teachers video-recorded their own lessons and chose short clips exemplifying how they use pauses to share with their colleagues. The teachers recognised a range of different ways of pausing and imagined their impact before trying out a range of combinations in their own teaching. Identification of this range of available choices was one outcome of the research. A further finding was the variety of factors teachers identified that influenced the impact of pauses. These orientated around aspects of the ground rules for interaction in their classes, the nature of the questions or prompts used, and consistency in their use of pauses.

Age range: *Secondary education*
Key words: *pausing; classroom interaction; working with videos*
Session type: *Research papers*
Duration: *30 minutes*

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Reflection in lesson study: The Figured World of initial teacher education

This presentation considers how Lesson Study (Lewis & Tsuchida, 1998) can be used to support professional development in Initial Teacher Education (ITE). The concept of figured worlds (Holland et al., 1998) will be used to analyse students' positioning in relation to various 'figures' involved in the Lesson Study process (e.g. the 'school-mentor' and 'university tutor'). We intend to reflect on which figures facilitate a more transformative experience for trainee teachers, one which allows them to develop into reflective practitioners. In this study, 50 secondary mathematics student teachers worked in small groups in selected schools in the North West of England with teachers, university tutors and researchers in planning, teaching, analysing and reflecting on observations, and re-teaching a research lesson. Selected participants were interviewed. Our findings will help us reflect on how best to employ Lesson Study in ITE. We argue that teachers that have trained through lesson study might be able to challenge accepted practice. In this particular case, the Lesson Study experience would represent a rupture from the taken for granted, as described by Holland (1989), where alternative figuring, that of the teacher researcher, can develop through reflection.

Age range: *Teacher education*
Key words: *Lesson Study; Figured World; professional development*
Session type: *Research papers*
Duration: *30 minutes*

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Developing South African primary learners' multiplicative reasoning: The impact of a short teaching intervention

This presentation reports on a pilot study examining the impact of an intervention aimed at improving the teaching and learning of multiplicative reasoning (MR), in particular, problem-solving drawing on MR. The intervention was carried out in a South African primary school with 342 learners across three classes in each of Grades 1, 2 and 3 (six- to nine-year-olds) and their teachers. Based on a modified learning study model, key understandings in MR were identified as desirable objects of learning with four lessons designed around these object of learning and taught collaboratively between a member of the research team and the regular class teacher. In this paper, we focus on the learners' understanding of MR as demonstrated through pre-, post- and delayed post-tests. The findings show that even with such a limited intervention significant learning gains can be achieved, many of which were sustained in the delayed post-test (which took place after a long school holiday). There are implications from these findings both for the assumptions made about the extent to which young learners can engage with MR and also for how it might be taught.

Age range: *Primary education*
Key words: *multiplicative reasoning; primary; raising attainment*
Session type: *Research papers*
Duration: *30 minutes*

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Making Numbers: An update and some questions

In stage 2 of our Nuffield funded research project, we have been looking at the affordances and constraints of the uses of different manipulatives in the teaching of aspects of number sense. In this session, we will present some of the issues that have arisen and invite discussion of their implications. Using the example of young children's understanding of the 'tricky teens', we will consider various discrete and continuous models of number and the complexities of cardinality and ordinality.

Age range: *Primary education*
Key words: *manipulatives; instructional resources*
Session type: *Research workshops*
Duration: *30 minutes*

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Raising attainment of middle-lower attaining GCSE students

Year 11 students throughout England are currently attending 'intervention' classes designed to raise their mathematics attainment ahead of their GCSE examinations, using methods of instruction that seem to have proven unsuccessful the first time they were taught concepts, and then again, unsuccessfully, in subsequent lessons. This research presentation reports on qualitative data from one class of middle-lower attaining Year 11 GCSE students who have been taught a range of mathematical concepts using multiple representations and using teaching designed to allow them to reason from key known facts. Data from lesson observation, student and teacher interviews and students' work will be analysed to interpret the impact of this small scale classroom enquiry.

Age range: *Secondary education*
Key words: *GCSE attainment; multiple representations; mathematical reasoning*
Session type: *Research papers*
Duration: *60 minutes*

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Effective teaching of GCSE Mathematics in Further Education colleges

Teaching large scale GCSE resits in FE colleges is a relatively new phenomenon that has not been researched. We know plenty about primary/secondary school teaching, but our knowledge about the specifics of teaching resit students is anecdotal. This research project - "What constitutes effective teaching for GCSE Maths resit students?" aims at defining best practice for students, teachers and senior leaders. It is run as a partnership between Gloucestershire College and the University of Gloucestershire, with students of Gloucestershire College being the focus group. In the current phase of the project we are looking at the students' attitudes towards mathematics and its learning, gained by surveying 700 students - the entire resit cohort - and doing focus interviews with 30 of

them. The presentation will cover findings from the survey, as well as brief description of the later phase of the project, which will focus on the teachers and policy analysis. This session aims at introducing the project to FE practitioners and those secondary teachers with an interest in teaching mathematics to disengaged learners. It will consist of a short presentation of the project finding so far, followed by discussion about the project design and chosen methodology – and possible future research questions.

Age range: *Further / Higher education*
Key words: *GCSE retakes; FE colleges; FE funding*
Session type: *Research papers*
Duration: *30 minutes*

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Transmaths special issue of five papers for 'Teaching Mathematics and its Applications'

The five paper authors will each present (i) an abstract, (ii) a key contribution to knowledge, and (iii) some implications for teaching practice for each of their papers now under review for the Transmaths TMA Special Issue (edited by Black & Williams, 2016). These focussed on the Transmaths projects (ESRC grants (ESRC RES-000-22-2890, RES-139-25-0241, RES-062-23-1213, and RES-061-25-0538). Collectively, they report original research involving qualitative and quantitative data analyses from empirical studies, and illustrate the use of Activity Theory lenses to gain insights into the activity systems in schools and university mathematics/engineering contexts of transition. They argue for developments of teaching and learning practices that are more connectionist, dialogical, and oriented towards problem-solving and modelling.

Age range: *Further / Higher education*
Key words: *transition; ChAT; identity; transmission pedagogy; measurement;*
Session type: *Research papers*
Duration: *60 minutes*

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Vernacular numeracies: Exploring the everyday numeracy events and practices of students in further education on pre- level 2 functional skills mathematics programmes

Many young people in England underachieve in mathematics during their compulsory schooling. Second chance educational opportunities in Further Education do not always lead to examination success. Adopting a perspective which sees numeracy as a social practice could provide affordances to reframe what we think of as legitimate competence in relation to mathematics and numeracy practices. This research, undertaken in a general further education college in an area of high deprivation in the North West of England, explores the informal numeracy practices students engage in, in their everyday lives. How these numeracy practices, conceptualised as vernacular numeracies, are used in vocational and functional mathematics learning, is also examined. Qualitative data was gathered from 18 participants, aged 16 – 18, studying on foundation level programmes. The data has been analysed using an 'ideological model' of numeracy as opposed to an 'autonomous model'. Initial findings suggest that students and their teachers place little value on students' everyday numeracy practices, even though these vernacular numeracies may be important in supporting student numeracy development. Pedagogical practices seem to re-inforce students' positioning as deficient. The social practice model may challenge, at a conceptual level, what it means to be numerate.

Age range: *Further / Higher education*
Key words: *Further Education; numeracy as social practice; numeracy events and practices; vernacular numeracies*

Session type: *Research papers*
Duration: *30 minutes*

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The beginnings of school-led teacher education

This report details the results from the School Direct Research Project undertaken by a team of academics from Manchester Metropolitan University. It concludes five years of research into the effects of school-led training on the rationale and composition of university teacher education and considers the impacts of recent changes on the teaching profession. Over 120 interviews were conducted with 70+ university-based teacher educators, and also school-based mentors and trainees. Data set covers 20 universities and 12 schools in north-west England. Additional comparative interviews were carried out in six other countries. Key findings to be discussed include School Direct: has altered how the content and composition of training is decided; has altered the balance of power between universities and schools, and in turn, their relationship with one another; has reconfigured how trainee teachers experience and understand practice-based pedagogical knowledge, or put more simply the relationship between theory and practice; has produced differing understandings of subject knowledge elements of training.

Age range: *Teacher education*
Key words: *School Direct*
Session type: *Research papers*
Duration: *60 minutes*

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Blending classroom and computing activities for mathematical resilience by making construals

Experience shows that practical classroom activities can be more effective than abstract mathematical exercises in enhancing students' mathematical skills and developing their mathematical resilience. Motivation and engagement are also promoted by learning mathematical concepts that relate to familiar activities, such as playing noughts-and-crosses. However, classroom activities typically take a great deal of time and effort to prepare and are hard to adapt. To address these limitations, some practitioners turn to electronic support. That said, conventional software development is problematic because it requires special expertise, and also requires a large investment in time and effort. Even after building up a collection of electronic resources, to add or adapt activities may entail redesigning from scratch. In this talk, we shall introduce an alternative approach to creating electronic learning resources based on 'making construals'. We shall demonstrate that by making a construal of a single topic, such as Donald Michie's Matchbox Educable Noughts and Crosses Engine (MENACE), we can readily derive interesting related classroom activities for primary and secondary mathematics education. These can introduce abstract mathematical concepts, such as pattern recognition, statistical analysis, understanding symmetry and motivate these with reference to more practical topics, such as game design, game-playing strategies and machine learning.

Age range: *Not age specific*
Key words: *mathematical resilience; classroom activities; making construals*
Session type: *Research workshops*
Duration: *60 minutes*

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Ethnic and EAL measures or underlying migrant history: Impact of English as an additional language on secondary mathematics attainment across ethnic, gender and social class differences

This paper reports on mathematics educational attainment data and the contextual value added to students' GCSE (General Certificate of Secondary Education) mathematics grade in England by modelling the interaction effect of ethnicity, social class, gender and EAL through multi-level modelling. Though first setting out to investigate Pakistani students' mathematics attainment patterns, this paper shows it is the interaction of EAL with ethnicity that matters. EAL ethnic minority students from poorer homes are predicted to have better outcomes than their non-EAL counterparts. Finally, the importance of the EAL result is the key idea/interpretation that there was nothing essential about one's Pakistani ethnicity, which is somehow having an effect on one's capital, and so access to opportunity. This is evident in the interactions of ethnicity with EAL, revealing that (perhaps) the cultural history of the group as recent migrants seems to be what is significantly likely to be indicative of the shared cultural-historical experience that probably matters. Thus, EAL when crossed with Pakistani ethnicity becomes an indicator of a certain capital, while at the same time being interpreted as an indicator of linguistic deficit. This then warrants further investigation in terms of qualitative investigation to unravel the underlying causal factors.

Age range: *Secondary education*
Key words: *mathematics attainment; ethnicity; English as an additional language; gender; social class*
Session type: *Research papers*
Duration: *30 minutes*

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Building and sustaining active research collaborations with teachers of mathematics

Many researchers are deeply concerned with ensuring they have opportunities to work with and involve teachers in the process of doing, and engaging with the findings, of mathematics education research. The current educational landscape in which teaching schools and Maths Hubs are being encouraged to engage with and participate in more 'research-informed' practices offers a range of challenges but also opportunities to develop new collaborative ways of working. The working group will meet to share and discuss experiences, current projects and initiatives with a view to developing a range of resources that might inform and support future work.

Age range: *Not age specific*
Key words: *collaborative research; research-informed practices; lesson study; practitioner research*
Session type: *Working groups*
Duration: *60 minutes*

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Sustainability and mathematics education

In the first half of this session, Alf Coles will present on Gibson's notion of levels of learning. In the second half of the session, we will work on task design, using Gibson's levels of learning as a heuristic for rich mathematical and global tasks.

Age range: *Not age specific*
Key words: *sustainability*
Session type: *Working groups*
Duration: *60 minutes*

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Concrete materials for learning algebra

Many practitioners have experienced the struggles students have with learning algebra, but cannot find a means to deliver the ideas in a hands-on way that is not very restricted to purely concrete usage. For example using cups as variables and counters as constants can be a useful way of presenting $3x + 1$ (3 cups with an unknown but consistent number of counters and one extra counter), but is unhelpful for referring to negatives. This workshop covers a way of representing algebra using 'playing cards' that allows students to understand collecting terms, substitution, expanding and factorising linear expressions, solving equations (including those with variables on both sides), graphing and simultaneous equations, in the context of a game. This material derives from my doctoral thesis, and has now been tested in both primary and secondary schools. (Primary children were able to solve equations such as $2x + 6 = 4x + 2$ after three hours work, never having tackled algebra before) Those who attend will be able to use samples of the playing cards at the workshop and will be given a document that can be freely photocopied and used in schools.

Age range: *Primary and secondary education*
Key words: *instructional resources; algebra; primary; secondary*
Session type: *Research workshops*
Duration: *60 minutes*

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The weakest link of Polya's stages through integral problem solving process: What to check

In this study, the integral volume problem solving processes of university students were analysed with respect to the Polya's stages and the look back stage focusing on "the changes students make through integral volume problems solving process after the solution is completed". Participants of the research were 142 students who had been chosen from four different faculties of two State universities in Istanbul. Additionally, 3-4 students were interviewed by using semi-structured interview technique. Integral Volume Test, which is developed by the researchers, was administered to the participants. The answers given to the Integral Volume Test were primarily analysed with descriptive statistics by using Polya's problem solving stages. Afterwards, each stage was analysed with content analysis. Interestingly, at the end of their integral volume problems solutions, even though almost all the students performed the look back stage, almost a quarter of the students modified or corrected some parts of their solutions. Erasing, crossing out and emphasizing were dominated actions students took in the look back stage. Consequently, it appeared that the participants' movements in the look back stages occurred in three phases: one is from the beginning of solution to the end of the solution or vice versa or among the stages of the solution irregularly.

Age range: *Further / Higher education*
Key words: *integral volume; problem solving; Polya's stages; look back*
Session type: *Research papers*
Duration: *30 minutes*

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Developing algebraic language in a problem solving environment: The role of teacher knowledge

In this presentation, we will describe a teaching sequence designed by a team of three mathematics teachers in Spain to enable a group of 13 to 14-year-old students to develop algebraic language through problem solving. Problems are introduced which provoke the thinking needed to solve systems of linear equations, without formal instruction in standard method, such as variable elimination. We consider the mathematics-related knowledge that the teachers used while implementing these tasks, using the Knowledge Quartet (KQ) model to analyze this knowledge. In particular, we show how the connections that the teacher makes between different representations of the same concept are key for the students to acquire algebraic language as one way to solve certain problems.

Age range: Secondary education
Key words: quartet knowledge; algebra; problem solving
Session type: Research papers
Duration: 60 minutes

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Improving children's place value understanding using the Japanese abacus

This study reports on the effectiveness of an 11-week intervention programme based around the Japanese abacus. This was conducted on twelve Years 3 and 4 children who were identified as underperforming by their teachers at a primary school in Nottinghamshire. The effectiveness of the programme was measured using Chan et al.'s (2014) place value assessment test, and self-designed arithmetic tests. These were administered at pre- and post-intervention stages to both the experimental group and a control group of thirteen better performing students chosen by the same school. The experimental group's scores improved on average following intervention by 89% in arithmetic and 49% in place values. These were significantly better than the improvement in performance of the control group, whose results rose on average by 25% and 4% respectively - although this may partially reflect a ceiling effect on possible test scores. These findings are consistent with earlier research which has shown that physical manipulation enhances children's abilities to visualise groupings of numbers. The results suggest that there might be important and timely benefits from using the Japanese abacus in primary school classrooms given the emphasis on place value understanding in the latest UK Primary Mathematics Curriculum.

Age range: Primary education
Key words: place value; Japanese abacus; maths intervention
Session type: Research papers
Duration: 60 minutes

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STEM hidden in elementary education: Seeing the pattern or living the moment by experience

Elementary schools offer unique opportunities for integrative approaches to STEM education that is expected to be integrated in higher education. Since elementary teachers are required to teach mathematics and science, courses nested into each other. These courses lay the foundation for the future STEM learning. However, elementary teachers are unprepared to guide students on the path to higher-level success in STEM fields. Therefore, this current study sets out to examine elementary pre-service teachers' perceptions of STEM

education. In this qualitative study, data were collected through using open-ended questions. These questions administered to 50 junior elementary pre-service teachers to determine their perceptions of STEM education. These pre-service teachers were enrolled in elementary teacher education program at a university located in northwest part of Turkey. Results of the study revealed that some of them thought integrated teaching approaches might not be useful for those who are not interested in STEM fields. Others were also concerned that these approaches could be confusing for students. This study showed that elementary pre-service teachers' perceptions of STEM education shaped by their experiences gained in science and mathematics education method courses. Since these courses generally taught as separate subject instead of integrative approaches, most of the pre-service teachers are unable to see these courses construct the foundation of STEM learning.

Age range: *Teacher education*
Key words: *pre-service teachers; elementary; STEM education*
Session type: *Research papers*
Duration: *30 minutes*

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Five decades of mathematics education research

Mathematics education as a research domain is approaching its fiftieth anniversary: Educational Studies in Mathematics was first published in 1968, and the Journal for Research in Mathematics Education followed soon after in 1970. How has the discipline changed over this period? Here we explore this question empirically, using a technique adapted from computational linguistics. Using this bottom-up approach, we identified 30 main "topics" that have occupied mathematics education researchers over the years, and explored how their prominence has changed over time. Our analysis raises questions about whether Lerman's mid-1990s "social turn" really was a turn, and brings into sharp focus what we might call the early-1980s "quantitative cliff".

Age range: *Not age specific*
Key words: *education research; history of research; educational theories*
Session type: *Research papers*
Duration: *60 minutes*

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Patterns of interaction that encourage student explanations in mathematics lessons

In this session, we explore three different interactional structures, which will be discussed in the session, that result in students offering explanations or reasoning in their responses to a teacher. Students explaining their mathematics is key part of the teaching and learning of mathematics yet there is little research into how to enable and support students in giving these explanations. All whole class interactions from 17 naturally occurring lessons with 8 different teachers were analysed. Using conversation analysis, we look at situations where students gave explanations of some form in order to identify features of the preceding interaction that provoked the student into offering their explanation.

Age range: *Secondary education*
Key words: *classroom interaction; explanations; conversation analysis*
Session type: *Research papers*
Duration: *30 minutes*

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Research at the boundaries of home and school: Working with or against the 'system'?

This session has been prompted by some reflections on the Everyday Maths project, in which we developed and carried out workshops to empower parents to support children's mathematics learning. The workshops positioned parents as experts – drawing on their knowledge about their own children and family activity. This project was completed in January 2015, but received an 'Impact acceleration' award to develop resources and disseminate findings from the research. Over the last year, we have been grappling with the difficulty of conceiving of what 'impact' means for a project that does not fit existing practices and policies in many schools. The perspective taken in the project – parent-centred; a focus on family interactions, rather than cognitive development; mathematics arising in everyday family activity – does not easily mesh with some school perspectives – teacher-centred; assessment-driven; individual/competitive. Working with such questions of impact in the context of 'parental engagement', 'parental involvement' and so on has encouraged us to return to wider questions of how to work across perspectives in mathematics education research. This session will thus focus on our current thinking about how to theorise research at intersubjective/interperspectival boundaries – using our experience working with parents and primary school teachers as examples of apparently incompatible perspectives.

Age range: *Primary education*
Key words: *parents; family learning; impact*
Session type: *Research papers*
Duration: *60 minutes*

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A conceptual approach to assessing achievement and progress in mathematics

Mathematics exams tend to assess general achievement through testing procedural knowledge across a sample of mathematical domains. In this presentation, I will describe an alternative approach that instead tests conceptual understanding across domains. Open-ended test questions, which focus on specific concepts (e.g. fractions), are administered to students and the responses scored using a comparative judgement technique. The scores are then aggregated to produce an overall score of general mathematical achievement for each student. I will present two recent studies conducted with Key Stage 3 students. The findings suggest that the approach, if carefully designed, produces valid and reliable outcomes when used to assess general achievement and progress in school mathematics.

Age range: *Secondary education*
Key words: *assessment; conceptual understanding; comparative judgement*
Session type: *Research papers*
Duration: *30 minutes*

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Teachers' perspectives on using graphing calculators in advanced mathematics

Graphing calculators are one of the technological tools used in today's classrooms. They are small, portable, and battery-powered, and have a multi-line display on which graphic objects can be drawn. I conducted a descriptive intrinsic case study to address eleven teachers' perspectives on using graphing calculators in a high school Functions, Statistics, and Trigonometry (FST) course developed by the University of Chicago School Mathematics Project (UCSMP) for 11th-grade students. Schools were selected taking into consideration their population and

their locations in terms of representing as much diversity as possible across the United States. Teacher interviews showed that four teachers used graphing calculators mostly in statistics topics. Five teachers used no calculator tests or questions as part of their testing process, either as an entire no-calculator test or a test on which some portion did not allow calculators. Seven teachers talked about their need to have a manual showing the steps for using graphing calculators with Computer Algebra System (CAS) they received on loan from UCSMP. Three teachers reported that there was a need for time and in-service training to help those using graphing calculators with CAS to learn how they worked. This study has important implications on professional development programs to improve usage of graphing calculators. The research is based on Ilyas Karadeniz's dissertation, conducted under the direction of Dr. Denisse R. Thompson.

Age range: *Secondary education*
Key words: *functions; mathematics teaching; statistics; technology use; trigonometry*
Session type: *Research papers*
Duration: *30 minutes*

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Usability of cognitive maps to analyze beliefs related to mathematics

Research on beliefs of students, teachers or prospective teachers related to mathematics is one of the most studied areas among many researchers in mathematics education. The difficulty of measuring beliefs has forced researchers to use various methods in the investigation of beliefs. One of these methods is using cognitive maps, which present a holistic image or picture of individuals' values and beliefs and how the relationships between these elements. In literature there is no research about cognitive maps used with the beliefs related to mathematics. In this context, the purpose of the study is to examine this kind of cognitive maps. In the study, a four-stage analysis process is used which was suggested by Hewson and Hewson (1989) and generalized to cognitive maps by Irez (2006). Examples for both analysis process and cognitive map are also given from our study which is still being conducted with 7 senior pre-service mathematics teachers from a primary school mathematics education program in a university in Istanbul, Turkey.

Age range: *Not age specific*
Key words: *beliefs; beliefs related to mathematics; cognitive map*
Session type: *Research papers*
Duration: *30 minutes*

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Problem solving and educational interactive games: A case study of Year 6 children

The advancement in technology has had a direct impact on how we teach and learn mathematics as well as the production of knowledge. Over 98 percent of school age children play video games in the UK (IAB, 2011). However, the role of video games in teaching and learning is a source of controversy among many educators, parents, researchers and in the media for quite some time (Perrotta et al., 2013). This paper reports on a PhD pilot study carried out on problem solving and interactive games from seven Year 6 children in Greater Manchester. The aim of the study was to explore how interactive games can be used in a small group setting to support children's problem solving strategies. Based on this aim, the overarching research question was: in what ways can interactive mathematics games support children's problem solving skills? Case study data was collected during lunchtime sessions over a five day period based on purposive sampling. Children completed various mathematics challenges on five interactive video games. Multiple data collection methods were used: interviews, direct observations and documents. Findings will be discussed with regard to how children were using some problem solving strategies when they were playing interactive games.

Age range: *Primary education*
Key words: *problem solving; educational interactive games; games and learning; interactive computer games; educational mathematics video games*
Session type: *Research papers*
Duration: *30 minutes*

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The students' involvement in a workplace inquiry activity: Solution of the solar panel problem

This research presentation is part of the European Programme MASCIL and refers to the solution of the *solar panel* problem by 11 heterogeneous groups of the students of upper secondary school classroom in Greece (Year 10). In particular, by using audio and video recordings and qualitative content analysis, it discusses the ways in which collaborative inquiry learning and authentic workspace, that arises from common real life situations and its solution is utilized mainly in them, can be used to bring out and enhance the students' mathematical argumentation. The results of the experimental teachings show that, the workspace context and the inquiry activity favoured the involvement of students in solving the problem. The negotiations to cover the surface with a maximum number of photovoltaic cells that can be placed on the roof of a house and the students' difficulties in trigonometry and three-dimensional space are notable. A detailed description of the problem is available in the mascil-project website (<http://www.mascil-project.eu/classroom-material>).

Age range: *Secondary education*
Key words: *inquiry activity, authentic workspace, trigonometric ratios, students' involvement*
Session type: *Research papers*
Duration: *30 minutes*

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Why is students' understanding of arithmetic with numbers below one so poor?

Fraction and decimal arithmetic are crucial for later mathematics achievement and for ability to succeed in many professions. Unfortunately, these capabilities pose large difficulties for many children and adults. A major reason why learning fraction and decimal arithmetic is so hard is poor conceptual understanding of how and why the arithmetic procedures work and why they are legitimate. To test this hypothesis, we asked children and adults to judge the direction of effect of fraction multiplication and division. Specifically, we presented typical US secondary school students ($n = 59$) and Canadian pre-service teachers ($n = 41$) (purposive sampling in both cases) with problems of the form, "Is $N1/M1 + N2/M2 > N1/M1$," where $N1/M1$ was the larger operand. For example, one problem was "True or False: $31/56 * 17/42 > 31/56$." As expected, both students and pre-service teachers performed well below chance on both multiplication and division of fractions less than 1. For example, only 33% of pre-service teachers correctly judged that the product of two fractions smaller than one would be less than the larger of the fractions. We have also shown analogous misconceptions with decimal multiplication and division. The educational implications of these findings will be discussed.

Age range: *Secondary and Teacher education*
Key words: *fractions; decimal; arithmetic; misconceptions; pre-service teachers*
Session type: *Research papers*
Duration: *60 minutes*

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What to do with what they already know? Folding back as a pedagogical tool

This session will report findings from a project focusing on teaching for mathematical understanding. Through drawing on elements of the Pirie-Kieren Theory for the Dynamical Growth of Mathematical Understanding and the notion of “problematic met-befores” (McGowen & Tall, 2010) - prior knowings that are insufficient for a new context - the study explores how teachers might encourage students to build mathematical understandings that are explicitly connected to their prior knowledge. More specifically, we consider how the purposeful teaching action of encouraging “folding back” (a theoretical metaphor that describes the process of examining, modifying and thickening prior understandings and knowings) can overcome problematic met-befores and promote understandings that are conceptually connected. The project consists of video-based case studies of secondary school teachers in Canada, and the data were analysed through repeated viewing of the videos and the creating of detailed sets of analytic notes. In this session, we will focus on one teacher, Mort, as he works with a Grade 12 class on the concept of vectors in three-dimensional space, and share extracts of video data to illustrate his use of folding back as a pedagogical tool.

Age range: *Not age specific*

Key words: *growth of understanding; prior knowledge; folding back*

Session type: *Research papers*

Duration: *30 minutes*

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If ‘good enough’ is sufficient for primary mathematics teaching, do we need excellence?

Teachers face persistent demand to achieve ‘excellence’ in teaching, by policy makers who do not define what is meant. These same teachers encounter paradoxes as they endeavour to reconcile their personal and professionalism identity, and the political agenda. For this small-scale research, the question was ‘How is excellence in primary mathematics teaching perceived by primary mathematics teachers?’ Four different teacher groups in the south of England (two student teachers; two experienced teachers embarking on becoming MaSTs; three MaST graduates; and three primary mathematics HEI lecturers) were drawn through a purposive, specialist sampling method process and interviewed producing narrative and mind-maps. An interpretative, thematic approach to analysis was adopted. One unexpected outcome was that ‘good enough’ teaching would suffice. The research indicated that targets in primary school can be met by less than excellent teaching and it might be questioned whether better than good teaching is essential, necessary or achievable by all teachers. However, the research also revealed reservations in the acceptance of a standard that is sufficient, questioning enduring long-term gains. Encompassing both aspirational and functional principles, such as societal gains, aesthetic and intrinsic value, there are purposes and benefits in mathematics education that are above and beyond meeting the targets.

Age range: *Primary education*

Key words: *excellence; targets; mathematics; primary*

Session type: *Research papers*

Duration: *30 minutes*

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‘When Mamta met Nancy and Emily to do some mathematics’ – what intellectual and personal resources do primary student teachers draw on when doing and considering the teaching of mathematics?

How student teachers fare when teaching mathematics is of importance to many stakeholders: the children they teach, their parents/carers, the schools they work in, the university that allows them to qualify and themselves. There is a moral purpose attached to the effective teaching of mathematics (or any subject); as a profession, we want all children to achieve. Regardless of the policy environment, it is essential that student teachers start their teaching career confident about teaching mathematics and committed to professional self-improvement as a reflective practitioner. As a teacher educator, I was keen to explore the intellectual and personal resources students on a BA (Hons) primary programme draw upon to enact their mathematical self ('I') and mathematical teacher identity. Two female primary student teachers in the north of England, as chosen using convenience sampling strategy, participated in the study. The four dimensions of Rowland's knowledge quartet were used as a theoretical framework within which to interrogate findings. I report on what happened on the day that we did some mathematics. There are some real surprises, contradictions, tensions and rather heart-rending moments.

Age range: *Primary education*
Key words: *primary teacher subject knowledge; knowledge quartet; teacher identity*
Session type: *Research papers*
Duration: *30 minutes*

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Implementing multi-touch tables into classroom: In what ways are students engaged in an interactive mathematical activity "around the table"?

This presentation is about the design, development and evaluation of an interactive application on multi-touch table in order to enhance students' learning of algebraic generalization in a collaborative learning environment. Multi-touch table technology allows users to work together on a task displayed on its screen supporting rich forms of interaction among them. In order to investigate the context in which an interactive application with such educational aspects occurs, a literature search was conducted on generalizing patterns and a small pilot fieldwork in the classroom. A paper prototype, in the form of crafts, was designed and implemented into two classrooms of 26 students (12-13 years old), in an experimental school of Athens, Greece. Data was analysed with SOLO (Structure of Observed Learning Outcome) taxonomy developed by J. Biggs. Outcomes obtained from field research led to the design requirements that the final interactive prototype should meet. Thereafter, the final prototype was evaluated in laboratory by two focused groups of users. The results show us that students engaged in high levels of oral interactions that affected the understanding of the subsequent algebraic concepts introduced, encouraging us for further research.

Age range: *Secondary education*
Key words: *multi-touch table; activity; algebraic generalization; generalizing patterns; paper prototyping*
Session type: *Research papers*
Duration: *30 minutes*

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Muddled methods: Student responses on a mini-ratio test

This presentation explores the large variety of interesting (but often incorrect) approaches and methods used by the students in a Year 7 classroom in a London school while engaging an ICCAMS Maths mini-test on ratio. Twenty eight students each wrote two different versions of the test, thus giving fifty six test scripts for analysis. The test scripts were analysed to identify different methods used, and the multiplicative models suggested in Hart

et al. (1978) provided a loose framework for categorising these methods. Samples of student working will be provided for analysis and discussion. A tentative observation will be made with respect to the inconsistency of students' methods and the preferencing of additive over multiplicative strategies.

Age range: *Secondary education*
Key words: *ratio and proportion; multiplicative reasoning; sample student work*
Session type: *Research workshops*
Duration: *30 minutes*

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A mathematics intervention project: A Level students working with pupils in Years 5 to 8

Nationally there is an acute shortage of mathematics teachers. In central Manchester, performance in mathematics is close to national average in primary, but lower at GCSE. There is a shortage of teachers of mathematics and high turnover amongst those teachers that schools manage to recruit. One large sixth form college with 1,000 A level mathematicians wanted to develop an intervention that would help to raise the profile of mathematics in local schools. Students were invited to apply to be part of the intervention and out of 120 applicants, sixty were selected following an interview. The college timetabled a regular slot to facilitate the participation of students in both preparatory tasks and the intervention. We describe the intervention and the students' responses. We think this was a successful intervention on many levels and hope it might inspire similar initiatives elsewhere.

Age range: *Further / Higher education*
Key words: *mathematics intervention; Sixth form mathematicians; upper primary; lower secondary*
Session type: *Research papers*
Duration: *30 minutes*

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Using a second language to develop mathematical understanding

Mathematical reasoning and conceptual understanding are central to the national curriculum. We argue that a Content and Language Integrated Learning (CLIL) approach can support both aims. CLIL does not replace discrete subject teaching, but can provide a meaningful context for subject content and language learning. Our research examines the role of communication, specifically in a second language, in developing and consolidating conceptual understanding. We describe a small-scale intervention project based at Manchester Metropolitan University involving a self-selected group of six primary teachers. The teachers attended a series of four workshops, exploring the potential of Content and Language Integrated Learning (CLIL) pedagogy within primary mathematics, using the medium of French. The teachers tried the activities from the workshops within their classrooms and reported on the outcomes. Data collected consisted of tutor observation notes, supported by video-recordings. Semi-structured interviews were held following the final workshop. The data was analysed using a cognitive discourse function framework. Articulating their own ideas and understanding in a second language enabled the teachers to focus on the key elements in their explanations to others. They developed a deeper understanding of the relationship between conceptual understanding and communication and saw that communicating ideas can contribute to conceptual development.

Age range: *Primary education*
Key words: *CLIL; conceptual understanding; communication; language*
Session type: *Research papers*
Duration: *30 minutes*

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Performatics

Identity is argued as a means to understand mathematical learning in its sociocultural context and has been operationalised in research as stories we tell about ourselves and others. Over one academic year, I filmed three post-graduate students taking mathematics related courses at a University in Northern England as they constructed a drama from testimonies about their experiences with mathematics. My resulting film 'Performatics: performing stories about mathematics' addresses the problem of operationalising identity beyond the discursive to also consider embodied aspects of identity often missing from textual accounts (gestures, stance, body language etc). 'Figured Worlds' provided a lens of analysis; framing identity stories as performed in "figurative, narrativized, or dramatized worlds...in the form of a story or drama, a "standard plot" against which narratives of unusual events are told" (Holland et al, 1998, p. 65). Drama was theorised as a means to reflect a wider social conscience about mathematics where common stories as a 'standard-plot' become resources to drawn on in answering some imagined social audience. The filmed drama, which combined discursive and embodied aspects of identity, illuminated the performers multiple, often contradictory, mathematical performances from a 'standard plot' of mathematics anxiety to more unusual narratives of enjoyable, creative mathematics.

Age range: *Not age specific*
Key words: *Social Learning Theory; film; drama*
Session type: *Research papers*
Duration: *60 minutes*

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Using the history of mathematics in education

The new English National Curriculum states, "Mathematics is a creative and highly inter-connected discipline that has been developed over centuries, providing the solution to some of history's most intriguing problems". The history of mathematics provides an intriguing and engaging way of making some of the increased expectations in the new curriculum accessible to learners. In this working group session, we will consider the history of trigonometry – from the ratio of 'the run to the rise' in the pyramids to finding distances between stars in India and navigating the globe. Trigonometry provides an important area for making connections between mathematical concepts and skills: ratio, proportion, functions, and transformation of algebraic formulae, that are currently separated among the different headings of the Programmes of Study for Key Stage 3 and Key Stage 4 Mathematics. We are working with colleagues in Denmark, where the history of mathematics is an essential part of the curriculum, towards a conference on the History of Mathematics in Education, to be held at Bath Spa University in August 2016. Do come and work with us towards this exciting collaboration.

Age range: *Secondary, Further education, Teacher education*
Key words: *Key Stages 3 and 4; History; curriculum development; key concepts*
Session type: *Working Groups*
Duration: *60 minutes*

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"It was all led by them": Opening up opportunities for making mathematics through a children's exhibition

Mathematics in the Making (MiMa) (<http://www.mathematicsinthemaking.eu>, Project no. 539872-LLP-1-2013-1-IT-COMENIUS-CMP) drew on Pestalozzi's model of learning - from hand to heart to head - and that of Bruner in

which understanding develops from the enactive to the iconic and thence to the symbolic. It also recognised that learning is fundamentally social and that worthwhile learning is democratic. The MiMa partners produced "hands-on" practical mathematical activities for 8 to 10 year olds. Participating teachers experienced the activities themselves before running 'laboratories' based on the activities with their children. The distinctive feature of the MiMa project was that, throughout the laboratories, the teachers and children knew that they were preparing their objects and activities for public exhibition: the children were to display and explain their mathematics to others - their families, children from other schools and members of the general public. We will describe the exhibition in Sheffield and draw on our own reflections and those of participating teachers to argue that the experience gave the children an opportunity to exercise responsibility and autonomy with respect to their own mathematics and that this in turn led to many, particularly those previously low attaining, to become successful and more confident learners.

Age range: *Primary education*
Key words: *curriculum; practical; autonomy*
Session type: *Research papers*
Duration: *30 minutes*

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Assessment in primary mathematics: what, and who, matters?

School assessment is well-researched, but largely in relation to teaching and learning and especially ways in which it might help raise pupils' attainment (e.g. Hogden & William, 2006). Whilst this is important, assessment plays a wider role in terms of accountability. In a market-driven school system, pupil outcomes are increasingly used as a proxy measure for the educational 'success' of teachers and schools, creating new pedagogical dynamics within schools (Pratt, forthcoming). In a previous presentation, I reported on a small-scale study using semi-structured interviews with 12 Key Stage 2 teachers in the south west of England. This examined the way in which assessment is used to manage the success of teachers' own work as professionals. Here I use data from the same project to focus specifically on the ways in which this 'identity work' makes use of technologies of assessment and, through these, acts differentially on pupils, promoting some and potentially marginalising others. The analysis uses Bourdieu's (1986, 1998) capitals and teachers' habitus in the field of primary schooling; as well as 'illusio' to explain investment in these forms of professional activity. Whilst it is already clear that schooling acts differentially on pupils, this work explores the mechanisms by which this happens.

Age range: *Primary education*
Key words: *assessment; Bourdieu; differentiation*
Session type: *Research papers*
Duration: *30 minutes*

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Mediating role of technology: Prospective upper secondary mathematics teachers' practice

Effective use of technological tools during instruction helps students relate mathematical ideas and their deeper meanings (Mariotti, 2000). The question of how to use technological tools in effective ways to achieve these goals leads us to the mediating role of technology. This role is not only concerned with how to use technology in the classroom, but also with how technological tools make the interaction between teacher and students possible (Noss & Hoyles, 1996). This study examines how prospective mathematics teachers provide a mediating role for technology in the classroom and use technology with the purpose of achieving teacher-student interactions. For this aim, a multiple-case study was conducted. The participants of the study are five prospective upper secondary mathematics teachers who were enrolled to a teacher preparation program in a state university in Istanbul, Turkey. Data collection tools were semi-structured interviews, lesson observations and lesson plans each of which

includes a teaching activity using dynamic software. The analysis of data indicated that prospective teachers used technology with the aim of visualization of mathematical concepts and emphasizing relationships. They had difficulties with negotiating the meaning of mathematical concepts and establishing mediation between students, themselves and technological tools.

Age range: *Teacher education*
Key words: *prospective mathematics teachers; instructional technology; mathematics teacher education; mediation; interaction in the classroom*
Session type: *Research papers*
Duration: *30 minutes*

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'Collaboration' as a tool for professional development: The perspective of secondary school mathematics teachers in Zambia

The Ministry of Education in Zambia envisages that the current School-Based Continuing Professional Development (SBCPD) through lesson study will facilitate quality teacher professional. One key element of the SBCPD through lesson study is 'collaboration'. Teachers are expected to complete collaborative tasks: jointly plan lessons, peer observe the teaching of the planned lesson and conduct post-lesson discussions as a process for their SBCPD. Existing studies have presented the value and critical role of collaboration for teachers' professional development. This project particularly focuses on understanding the views of secondary school mathematics teachers in Zambia regarding 'collaboration' as a professional development tool. It draws on findings from the questionnaire (completed by 83 teachers), in-depth follow-up interviews and the Focus Group Discussions that were conducted. The findings show that despite being made to engage in the collaborative tasks, the teachers were not inclined to do so. The reasons for the teachers' reluctance to engage in the collaborative tasks, in the context described above, will be discussed and the implications this has for collaboration as a tool for professional development. The findings to be presented are from the main qualitative study on secondary school mathematics teachers' perspectives of Continuing Professional Development (CPD) in Zambia.

Age range: *Teacher education*
Key words: *collaboration; professional development; mathematics teachers*
Session type: *Research papers*
Duration: *30 minutes*

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Mathematical communication through a game: What do "I spy" with?

The purpose of this study was to examine 7th grade students' concept images and concept definitions of mathematics using the 'I spy' game, which involved twenty-six mathematics concepts focusing on numbers, algebra and geometry selected from the Turkish mathematics curricula. This game was administered to 90 students across three classrooms within two class periods in Turkey. Qualitative data, which are the verbal expressions of the concepts, collected from students were analysed using descriptive themes. Results of the study revealed that most of the students preferred to describe concepts instead of defining. In addition, it was observed that these students were unable to define certain mathematical terms such as equivalent fractions, rational numbers, etc. Instead, they tried to describe different features of other mathematical terms, for instance, prime numbers. This finding showed that some of the students seemed to have misconceptions about certain mathematical terms, for instance, extending fractions. Most of the students were able to guess 5 features of a mathematical term. More than half of the students had similar concept images and concept definitions. In summary, this study showed that the 'I spy' game could be used to increase interactions within the classroom and strategy development among students as well as revealing the misconceptions, concept images and concept definitions of the concepts.

Age range: *Primary education*
Key words: *mathematical games; concept image; concept definition*
Session type: *Research papers*
Duration: *30 minutes*

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Being systematic: Exploring the relationship between connectionist mathematics pedagogy and Vygotskian theory through the story of the development of a heuristic concept

Although Vygotsky's writings have already had much influence within mathematics educational research, his theory of scientific concepts offers pedagogy something more: A potential theorisation of connectionist (or reform) pedagogies which can help explain, cohere and further develop such teaching approaches. The paper explores and illustrates this relationship between theory and pedagogy through telling the story of one particular concept in one particular classroom. The concept is the heuristic concept of being systematic, and the class an undergraduate introductory course on the teaching and learning of mathematics. This course, with students who were potential primary school teachers and social workers with varying attainment in mathematics, involved much connectionist mathematical activity, alongside reflection upon that activity. Here, a series of the mathematical tasks, in some way related to the concept of being systematic, are discussed, and the concept's development within the class explored through the students' dialogue. As part of the wider theoretical perspective, two key issues are focussed upon. One is the nature of scientific concepts and, in particular, the relationship between abstract and concrete that they represent. This understanding encourages an emphasis on rich concrete experience as part of learning and explains the difficulty of merely transmitting the formal abstract. The second issue is the importance of the systematic connections of mathematics. Findings here encourage a greater, and earlier, emphasis on conscious attention to these than usually exists, even within connectionist or reform pedagogies.

Age range: *Not age specific*
Key words: *Vygotsky; concept development; connectionism*
Session type: *Research papers*
Duration: *30 minutes*

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The attitudes towards numeracy of teachers in three English secondary schools who teach subject other than mathematics

This paper reports on the initial analysis of data collected on the attitudes to numeracy of secondary school teachers in three schools in the Northwest of England who teach subjects other than mathematics. It examines their beliefs about mathematics, their perceptions of the role of mathematics in their teaching practices and their confidence in relation to teaching the conceptual understanding and mathematical skills necessary for academic success in their own specialist subjects. Data was collected from 267 teachers of a wide range of secondary school subjects. A multidimensional questionnaire was used to collect initial data which was followed up by semi structured interviews with a smaller sample of twenty-four participants. The data suggests an underlying tension between a public affirmation of the importance of mathematics in the wider secondary school curriculum and actual classroom practice which struggles to successfully integrate mathematical skills, knowledge and understanding. There are implications for mathematical education of non-mathematics teachers and the extent to which the lack of such provision impacts on the success of students in subjects other than mathematics

Age range: *Secondary education*
Key words: *attitudes; non-mathematicians; teacher training*
Session type: *Research papers*

Duration: 30 minutes

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Exploring differences and development in primary mathematics teaching in South Africa

In the context of a longitudinal research and development project focused on interventions to improve primary mathematics teaching, we investigated ways of describing differences in the quality of primary mathematics teaching across a relatively large sample of classroom teaching videos. In this context, we have developed a grounded framework for analysing the mediation of mathematics, linked to the particularities of South African evidence on the nature of primary mathematics teaching. Structure and generality are key foci within the framework. It has overlaps with elements of other frameworks - notably Adler & Ronda's (2015) 'Mathematical Discourse in Instruction' framework, and with aspects of Hill's (2010) 'Mathematical Quality of Instruction' framework. However, neither of these were use-able in their entirety for our purposes. In our presentation, we share data noting important aspects of the nature of primary mathematics teaching in South Africa. We go on to note elements of existing frameworks that relate to these aspects, while also pointing to key gaps. Our central focus is on sharing the framework we are considering, its theoretical antecedents, our methodological approaches, and initial analyses of differences in teaching that are leading to broad descriptors for the hierarchies we have developed.

Age range: Primary education

Key words: primary mathematics teaching; mediation; generality; South Africa

Session type: Research papers

Duration: 30 minutes

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Concept with no definition: Simplification of Trigonometric expressions

This study aims to discuss and examine simplification of trigonometric expressions that has no definition in mathematics curriculum, mathematics textbooks and mathematics education research. The research is a case study adopting the qualitative paradigm. The participants are 9 pre-services mathematics teachers from a mathematics teaching department in a state university in Istanbul, Turkey. Clinical interviews are conducted to ascertain pre-service teachers' concept images of simplifying trigonometric expressions. Interview questions consist of two parts. In the first part, it is aimed to examine pre-service teachers' definition knowledge about the simplification of trigonometric expressions. In the second part, pre-service teachers' simplification performance are examined through mathematical questions about simplification of trigonometric expressions. Data from the first part of clinical interviews, is analysed through content analysis. In the second part, Delice's (2003) model about students' simplification process of trigonometric expressions is used.

Age range: Not age specific

Key words: definition; simplification; trigonometric expressions; Delice's model of simplifying trigonometric expressions

Session type: Research papers

Duration: 30 minutes

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How to improve Key Stage 3 students' abilities to create mathematical proofs: An action research study in a British international school in Spain

The place mathematical proof has in the classroom is often debated by educational researchers. This study focuses on improving students' proving abilities in a British school in Madrid. Participants were 50 students, chosen using convenience sampling from high ability Year 7 and 8 sets. Participants were given twenty proof tasks over four weeks with varied teaching inputs, coded using a framework based on the pilot results of this study. Student proof responses were collected and coded using a proof framework, with categories including empirical evidence and visual demonstrations. This created a labelling system for the student responses, allowing open-ended qualitative data to be coded for analysis. The coded results were tabulated to look for patterns to identify any increases in individual proof types. The timeline of these changes was compared with the timeline of planned inputs to look for key influencing factors. From the results, the following hypotheses arose: *investigative lessons support students' logical argumentation; teaching on notation supports students' algebraic proving skill and when faced with unknown conjectures, students tend to resort to using empirical evidence*. Further investigation, using a larger sample and longer time period, would allow rigorous testing of these hypotheses.

Age range: *Secondary education*
Key words: *proof; action-research; empirical evidence; logical argumentation; algebraic proof*
Session type: *Research papers*
Duration: *30 minutes*