



Research papers and research workshops, all 40 minutes

Asghari, Amir

Liverpool John Moores University

Practising Signed Numbers at the Cost of Negative Variables

According to the Glossary of the Common Core State Standards for Mathematics, an integer is "a number expressible in the form a or $-a$ for some whole number a ." In a like manner, sometimes something like -3 is called a signed number as it is the number 3 prefixed by the sign $-$. As far as the arithmetic of integers is concerned, separating the sign from the whole part has in fact some computational advantages: it keeps us within the arithmetic of the whole numbers. For example, for multiplying integers, according to BBC Bitesize (or in fact, any other math resources from the 17th century onwards): "When the signs are different the answer is negative. When the signs are the same the answer is positive." Simply, we multiply the whole numbers and then adjust the signs. The purpose of this session is to provide some historical evidence to show the algebraic disadvantages of this common arithmetic practice of treating the negative numbers as the signed numbers.

Research Paper

Barmby, Patrick*

No More Marking

Comparative judgement of understanding in primary mathematics: A pilot study

A pilot study was carried out to assess the mathematical understanding of primary school pupils using comparative judgement. This was carried out in June 2018 and involved 728 Year 5 pupils from 56 English schools. Pupil scripts were judged by teachers from the schools involved in the assessment.

The judging of the scripts was followed up by an online questionnaire to the coordinators of the comparative judgement assessment in each school. From the 56 schools in the trial, 30 teachers provided feedback on the trial through the online questionnaire. The questionnaire explored the perceived validity of the assessment, the perceived ease for pupils answering the questions, and the perception of the judging process for the teachers involved. The overall aim of the study was to examine the effectiveness of a comparative judgement approach to assess mathematical understanding of primary pupils.

In this presentation, the results obtained from the comparative judgement assessment and the results of the teacher questionnaire are summarised. Based on these results, we put forward possible advantages of using a comparative judgement approach to assess understanding in primary mathematics, and suggestions for improving the process in future assessments.

Research Paper

Brown, Julian

University of Bristol

Characterising patterning of teacher-learner interactions in mathematics classrooms through classroom observations

Deliberate development of our practices, in and out of the classroom, is supported by explicit awareness of possibilities in the moment, expanding possibilities for action. My role as a mathematics teacher educator involves working alongside teachers as they work on their own awarenesses. I am interested in how classroom observations might be used as a mechanism to follow and support the awareness of awareness. This session makes use of observations of sequences of lessons taught by two different, experienced teachers of mathematics to consider possibilities for characterising particular teacher-class environments and, hence, to identify shifts in



these environments. Consideration is given to how such mechanisms might act as tools for development of in-the-moment awareness for practising teachers.

Research Workshop

Chancer, Libby

Swansea University

A design based research project: Exploring pedagogies that develop abstract and algebraic thinking within secondary school mathematics.

Within the current Welsh educational system, 'real life' problems have become a focus within Mathematics lessons. Pupils are given a worded or visual problem which often needs to be translated into a mathematical form to solve. The OECD refer to this process as mathematizing. It's often this process of mathematizing which causes difficulties for pupils. Pupils have to abstract during the translation, meaning they have to locate and express the mathematical structure within the problem. Only after abstraction is the problem in a form which is able to be manipulated and solved. This research is the 1st iteration in a design based research project that covers four intervention lessons. This project aims to develop specific pedagogies which support pupils to focus on mathematical structure and think abstractly and algebraically. This project justifies and evaluates the intervention lessons, explores the effectiveness of some of the activities and suggests possible changes for the next cycle of intervention.

Research Paper

Fitzsimons, Aidan*; Ní Fhloinn, Eabhnat

Dublin City University

Problem-solving with Highly-able Second-level Students

The module utilises collaborative problem-solving amongst small groups, with carefully chosen problems to organically introduce problem-solving strategies to students. Building on the work of Polya (1945) and Mason et al (2010), a problem-solving model was created to outline the problem-solving process in a group-dynamic. The aims of the module were not only to improve the problem solving skills of students, but also to build growth mindsets and mathematical resilience within them – a triad construct we have labelled 'problem-solving performance'. This talk will outline the design process of the module, and also the problem-solving model created.

Research Paper

Golding, Jennie

UCL Institute of Education

Financial literacy and the mathematics curriculum

In England the development of financial literacy and related applications features in several aspects of the intended curriculum, including, but not primarily, mathematics. We argue that the development of key mathematical concepts and of financial literacy have historically often been symbiotic. This paper draws on cross-phase classroom-close evidence to report changes to the preparedness of some students for engagement with concepts related to financial literacy. Student interviews suggested such changes were due to both changing patterns of family life and moves towards predominantly virtual, rather than physical, currency in many communities in England. We discuss the implications for organisation of both mathematics and financial literacy curricula, and suggest some ways forward.

Research Paper



Golding, Jennie*; **Grima, Grace, Redmond, Ben***

UCL Institute of Education, Pearson, Pearson

Teaching and learning for ‘moving goal-posts’: reformed A Levels in mathematics

Reformed English ‘A levels’ in mathematics, foundational to university calculus-dependent courses, were first assessed at scale in June 2019. They feature enhanced content-related scope and renewed focus on mathematical reasoning and problem solving. Related assessments had negligible piloting, and preparation time for resource development and teaching was pressured. Further, teachers/assessors typically had little experience teaching/assessing for the renewed foci. We used an institutional ethnographic lens to study the first 3 years’ enactment of the mathematics A Levels from the leading awarding organisation, and the impact on students’ learning, affect and pathways. We followed students and teachers in a fairly representative sample of 46 classes, drawing on termly data collection from participants and lesson observations. Initial ‘specimen assessments’ were largely considered valid and accessible; however, we evidence insecurity due to perceptions of ‘moving goal posts’. This related to perceived mis-alignment between published resources and emerging assessment materials, as well as confusion centred on assessment of ‘large data set’ work. Early final assessments were perceived as significantly more demanding than predecessor comparators and of limited reliability for many students. We analyse contribution to knowledge around introduction of curriculum aspirations at this level and discuss ways to address identified challenges.

Research Paper

Gratwick, Richard*; **Kinnear, George***; **Wood, Anna**

University of Edinburgh, University of Edinburgh, University of Edinburgh

An online course promoting wider access to university mathematics

In 2018, a new year 1 course, "Fundamentals of Algebra and Calculus" (FAC), was introduced at the University of Edinburgh to provide better support for incoming students with a range of mathematical backgrounds, by covering key topics from Advanced Higher and A-Level syllabuses. The course is delivered online, interleaving textbook-style exposition with videos of worked examples, interactive applets, and practice questions implemented in the STACK assessment system. The design of the course incorporates aspects of educational theory such as specifications grading, distributed practice, and the use of computer-aided assessment.

We will report on the progress of a Principal’s Teaching Award Scheme project, "Supporting transition to university mathematics with blended learning", which was funded under a special call through the university’s Widening Participation Strategy. This project uses a mix of quantitative and qualitative methods to investigate the impact of the course. We will present statistical evidence of FAC removing an apparent attainment gap, and data about the impact on students’ responses to the "Mathematics Attitudes and Perceptions Survey". We will also report initial findings on student’s opinions on both the design of the course and its advertising to current and prospective students, gathered through focus groups and interviews.

Research Paper

Helme, Rachel

University of Bristol

“I do it in my head and it is hard to explain”: Issues around showing working for one low attaining student in a GCSE resit mathematics classroom.

The concept of identity is described as saying, doing and relating in the context of mathematics as well as the positioning by oneself and others (Bishop, 2012; Grootenboer & Edwards-Groves, 2019). However, the interpretation of another’s work of identity could be seen as problematic due to the subjectivities of the objective other, and hence foregrounding the participants’ own voice in the



meaning making process affords the opportunity to consider identity work from within the 'lived experience'.

This session focuses on Darren, a participant from a small-scale study on the work of identity performed by low prior attaining students. Researcher observations noted a contrast emerging between Darren's ability to calculate the answer to a mathematical question and his inability to explain his mathematical thinking, both verbally and as written workings, and this theme was revisited in a subsequent Interview. The analysis used a voice-relational method called The Listening Guide (Gillingham et al, 2006) which listens for the coexistence of multiple voices within the narrative. For Darren, the voice of 'action' that states that he 'just needs to do it' contrasts with a more poignant voice of 'struggle' that provides an insight into his internal quandary around how to explain his thinking.

Research Paper

Ingram, Jenni*; Neale, Vicky; Funada, Natsuno

University of Oxford

Mindset and undergraduate mathematicians

Undergraduates studying highly mathematical subjects at university level often have a long history of success in mathematics, particularly in school-level mathematics. We report on the interim findings of a study of undergraduates who all achieved the highest possible grades in their school examinations but whose performance in university mathematics examinations reveal attainment gaps that are not predictable by prior attainment. Focusing particularly on attitudinal factors such as mindset and beliefs about ways of working with mathematics we examine students' perceptions of what enables or prevents them from being successful with their mathematics at university level using a mixture of questionnaires and interviews.

Research Paper

**Jameson, Ellen*, Horsman, Rachael, Macey, Darren,* Gould, Tabitha, Rycroft-Smith, Lucy,*
Majewska, Dominika*, McClure, Lynne**

University of Cambridge

Learning to use a map of mathematics: Case study contributions to formative evaluation of the Cambridge Mathematics Framework

The Cambridge Mathematics Framework is a digital reference curriculum framework for mathematics. It takes the form of a knowledge map alongside accompanying documents. We use graph visualisation and analysis to describe multiple dimensions of mathematics and to emphasise conceptual connections and their justification from mathematics education research, so that the CM Framework can serve as a useful tool in the design of coherent and well-aligned curricula and resources.

We will discuss the role of formative evaluation in our design methodology for the development of the CM Framework, with a specific focus on how results from four pilot implementations in the past year have contributed to our design. The four cases we will discuss correspond to key scenarios for the use of the CM Framework: Curriculum design (UNICEF Learning Passport mathematics curriculum framework), mapping tasks to the CM Framework, writing a maths textbook chapter, and use of the CM Framework ontology development tools to map ideas in computational thinking.

Research paper

Joubert, Marie; North, Marc; Wake, Geoff; Fletcher, Shobhna

University of Nottingham and ETF



Centres for Excellence in Mathematics: Perspectives on the implementation of a programme of interventions

Twenty-one Further Education or Sixth Form Colleges, in all areas of England, have been selected to take part in the government-funded Centres for Excellence in Mathematics (CfEM) programme. The Centres are expected to run a range of activities to improve the teaching and learning of mathematics, mainly targeting GCSE-resit students with prior GCSE Grades 1, 2 or 3. Each Centre is running pilot research trials in two of four themes (mastery, contextualisation, technology and motivation and engagement), which involves trialling mathematics lessons that foreground new teaching approaches. Each centre is supported by one of three Regional Mathematics Leads, with a key responsibility for running professional development cluster meetings with trial teachers loosely based on a lesson-study approach. All teachers and students in the research take part in surveys and eight colleges have been selected as case studies.

This presentation draws on our ongoing case study work to introduce the project in further detail. It provides an overview of the pilot year of implementing the trials from the different perspectives of the research team and the Regional Mathematics Leads. We discuss the design of the trials in terms of what the teachers were asked to do and present some emerging findings related to a) the design of the interventions and b) the professional development of the case study teachers.

Research Paper

Kinnear, George

University of Edinburgh

Investigating the effect of example generation and classification tasks on the learning of a new concept

When learning about a new concept, is it better to be prompted to generate examples for yourself, or to be provided with examples and non-examples to classify? I will report on an experiment investigating this question in an online course in introductory university mathematics, where students were randomly assigned either a generation or a classification task when first learning about increasing and decreasing sequences. Students' scores on subsequent assessment questions about this concept were used to compare the outcomes of the two approaches. The findings suggest there is not a significant difference between the two approaches, though there was a noticeable effect from the order in which follow-up questions of both kinds were asked. I will also discuss possible future directions for this work.

Research Paper

Lee, Stephen*; Walker, Matthew* & Straw, Suzanne

Mathematics in Education and Industry, National Foundation for Educational Research, National Foundation for Educational Research

The challenges facing schools and colleges engaging with post-16 mathematics support: findings from a national survey and in-depth case studies

Mathematics in Education and Industry's government funded Advanced Mathematics Support Programme (AMSP) has been in place since May 2018. During that period, the National Foundation for Educational Research has conducted a two-year independent evaluation of the programme. Key aspects of the evaluation include a national school/college survey into level 3 mathematics, teacher interviews and student focus groups, stakeholder feedback and interviews with AMSP programme leaders.

Schools have engaged in various AMSP support activities including teacher professional development and student enrichment and support, but they have faced key barriers such as releasing teachers/students from school and the cost or availability of teacher cover. Lack of support from senior leadership was not seen as an issue by many.

This paper draws on analysis from one of the largest responses (717 schools/colleges) to a survey



into post-16 mathematics since the GCSE/A level curriculum and examination changes took place in 2015. It also considers feedback from in-depth case studies that involved touchpoints with schools/colleges at two time points.

Research Paper

Lord, Ems*

University of Cambridge

'I want to help others': Why female A-Level Mathematics students reject undergraduate mathematics

Although university mathematics departments are increasingly maximising the potential of tracking undergraduate applications, there is a dearth of data regarding A-Level mathematics students who choose not to apply to those institutions. This pilot case study focused on a mixed group of Y13 A-Level mathematics students (N=18) attending an urban secondary school. The study was conducted after the closing date for their university applications. Using mind maps, the students were asked to share their reasons for continuing their studies to undergraduate level, as well as their choice of course and institution. The findings indicated several gender differences in their decision-making, including the perceived connection between their university course and their desire to help others. The possible implications of these findings are considered for their potential to inform future, larger-scale studies of interest to both schools and university outreach departments.

Research Paper

Mackrell, Kate; Johnston-Wilder, Sue; Brindley, Janine

Institute of Education, UCL; Warwick University; Independent Consultant

Human needs in the mathematics classroom: SDT, mathematics anxiety and mathematical resilience

Self-determination theory or SDT (Ryan & Deci, 2000a, 2000b) recognizes three fundamental human needs: competence, autonomy and relatedness and makes a distinction between autonomous and controlled motivation. There is extensive research evidence from a number of fields, including education, that the satisfaction of these needs is strongly linked to human well-being and performance and enhances autonomous motivation. Educational practices based on SDT are well in alignment with the ethos of "good" mathematics teaching recognized since the days of the Cockcroft report (1981) – but are practices which rely heavily on teachers' ability to create supportive and engaging classrooms, in an era when teachers are increasingly under pressure for results. Current work in mathematical resilience (MR) aims to give such teachers tools to better manage mathematics anxiety and promote mathematical resilience in their classrooms. This paper will explore the ways in which both the theory and practice of MR can be connected with SDT and illustrate the use of these tools in classrooms.

Research Paper

Makramalla, Mariam

University of Cambridge

**The Influence of Power Dynamics in relating to Mathematical Problem Solving:
A case study of Egyptian Teachers**

This session aims to uncover the different layers of power and influence in relation to the conceptualisation and dissimilation of shared knowledge on mathematical problem solving within the context of the Egyptian teaching and learning culture. Grounded on the Goodson Change Model, the session presents results of an empirical study conducted with teachers that operate under the governance of the national agenda for mathematics education in Egypt. The study adopts teacher focus groups to explore mathematics teachers' perceptions about problem solving tasks. Findings are then mapped against Stein et. al.'s (2000) Mathematical Task Analysis Guide which acts as an



analytical framework of the study. Results show that, despite being governed by a rigid national curriculum, the schooling culture plays a crucial role in counter-balancing the influence of the national agenda, thereby influencing teachers' perceptions on mathematical problem solving. Future work calls for different approaches of fostering and empowering school cultures operating in similar compliance based cultures of mathematics instruction in order for them to become change agents to the wider community.

Research Paper

Mathieson, Rachel*; Homer, Matt

University of Leeds, University of Leeds

“Core Maths should prepare students for vocational and academic study.” Does it?

Core Maths qualifications, now in the sixth year of being offered, are intended to contribute towards increasing post-16 maths participation in England. Core Maths technical guidance (Department for Education, 2018) states that Core Maths courses should prepare students for the varied contexts they are likely to encounter in vocational and academic study and in future employment and life. The guidance states that the qualifications are valuable for students progressing to higher education courses with a distinct mathematical or statistical element, such as psychology, geography, business and management, and for students aiming for careers in professional, creative and technical fields. In this session, we explore data from a three-year, mixed-methods, longitudinal study on Core Maths, funded by the Nuffield Foundation, looking for evidence relating to how, or whether, Core Maths may support the study of the broad range of curriculum areas in which students are engaged, whether their programmes lead to higher education, apprenticeships or employment.

Research Paper

McAllister, James*; Cantley, Ian

Queen's University Belfast

Gender differentials in mathematical achievement: Insights from a multilevel analysis of high-stakes examination results

The gender similarities hypothesis states that males and females are similar on most, but not all, psychological variables. The current study involved multilevel analysis of high-stakes (GCSE) examination results taken by students in Northern Ireland during summer 2016 to investigate gender differentials in mathematical achievement. Evidence was found to support the gender similarities hypothesis with respect to both overall mathematical attainment and domain-specific attainment. Similar conclusions were drawn from the current study as have been reported in studies into gender differentials using data from low-stakes international large-scale assessments (such as PISA and TIMSS) in Northern Ireland. This suggests that previously-expressed concerns in the literature about the viability of using data derived from low-stakes international comparative assessments to accurately assess gender differentials in achievement may be unfounded. The methodology employed in the study offered insights into mechanisms for promoting greater gender equity in mathematical achievement, and may have potential applications for other jurisdictions with an interest in this area.

Research Paper

Njaru Mbogo, Harrison

University of Tasmania

Building Mathematical Resilience: A Case study of Grade Three Children Experiencing Mathematics Anxiety.

Mathematical resilience is defined as a positive adaptive stance to mathematics that allows children to function optimally in a mathematics lesson. Therefore, children experiencing mathematics anxiety require mathematical resilience to aid optimal functioning in mathematics lessons.



Interestingly, mathematics anxiety research focuses on maladaptive response to learning mathematics. Against this background, this study contends that the mathematical resilience children require to aid mathematics learning is a consequence of various attributes including, daily classroom mathematics instructional strategy, the nature of mathematics itself, and pervasive beliefs about mathematical ability being fixed.

This PhD study intends to determine why grade three children are experiencing mathematical resilience deficits in Kenya. Studies in Kenya reveal that one third of grade three children cannot compute grade two mathematics and almost half of grade three children are learning mathematics below official curricular requirements. In this sense, this study intends to determine if these low attainments are due to mathematics anxiety and lack of positive adaptive stance.

Evidence shows that mathematical resilience can be built when school ethos encourages children to see that success in mathematics require struggle. This study will employ qualitative and quantitative research design. In addition, this study will employ semi-structured guided sets of interview with teachers children and parents, classroom observations, informal conversations and pre-test and post-test. Data will be analyzed using quantitative and qualitative statistics approach. Validity will be ensured through inter-rater validity verification and instrument internal consistency will be ensured through Cronbach's alpha coefficient test.

Research Workshop

Papadaki, Evi* & Biza, Irene*

University of East Anglia, University of East Anglia

Conceptualising the 'discourse at the mathematical horizon': Looking at one teacher's actions beyond the "mathematics of the moments"

This presentation introduces part of a larger study on secondary teachers' mathematical and pedagogical discourses. Specifically, the study investigates mathematical and pedagogical discourses that are significant to the coherence of mathematical ideas and practices that go beyond the mathematics of the moment, namely the content of a specific teaching and learning situation. In a previous BSRLM presentation, we explored the different narratives on the notion of 'knowledge at the mathematical horizon' in the existing literature. This time, we focus on a small set of data trying to identify characteristics of what we tentatively call teacher's 'discourse at the mathematical horizon'. The findings will be discussed by drawing upon elements from Ball & Bass' (2009) initial conceptualization of the mathematical horizon such as teacher actions on noticing, finding significance in, and giving meaning to students' mathematical ideas. The data collected are from lesson observations and pre- and post- observation interviews with a newly qualified mathematics teacher. Findings from the preliminary analysis illustrate links between teacher's actions and her reflections on these actions. Also, analysis of critical incidents when the teacher went beyond the mathematics of the moment together with her reflections suggest characteristics of her 'discourse at the mathematical horizon'.

Research Paper

Parish, Alison

Unaffiliated

Teachers of school mathematics; developing and learning knowledge and skills as illustrated by the case of digital technology.

New curricula often demand a change in how a subject is taught or includes new content but how do teachers face these demands? In mathematics 'new' initiatives have included Mastery, digital technology, changes at A-level, new courses while other courses have been phased out or changed such as decision mathematics (A-level) and the use of mathematics (GCSE) and Key Skills. In primary schools, material from the lower secondary curriculum is now included. A key issue is motivation and enthusing busy, and sometimes over-stressed, teachers to develop their knowledge and part of this how and when they have access to training and support from others.



This paper uses the views of trainee teachers and practising secondary teachers about learning to develop knowledge and skills in the use of digital technology and looks at whether their expectations are realistic for developing these. It also considers whether existing systems are accessible to all interested teachers and whether teaching/learning methods employed are appropriate for all. Although my research was centred on digital technology, findings can be applied elsewhere, within and outside of mathematics teaching.

Research Paper

Paschalis, Ioannis Yiannis

Brunel University

Finding a remedy for the illusion of linearity through TPACK.

Students tend to apply linear thinking in order to solve geometrical problems with faster pace. Focused more on students' difficulties in discriminating proportional relationships from nonproportional ones (De Bock et al., 1998; Modestou & Gagatsis, 2007; Van Dooren, De Bock, Janssens & Verschaffel, 2008) and understanding additive and multiplicative relationships (Fernandez, Llinares, Van Dooren, De Bock & Verschaffel, 2010; Misailadou & Williams, 2003; Van Dooren, De Bock & Verschaffel, 2010). Illusions of linearity have been troubling mathematics educators in the last twenty years. Even though it has been heavily researched no one found a remedy for this misconception so far.

The literature review showed that students mostly have trouble when working with the area and volume of reduced and enlarged shapes in such a way that "most students from grade 5 to grade 8 erroneously believe that if the sides of a figure are doubled to produce a similar figure, the area and volume also will be doubled" (National Council of Teachers of Mathematics [NCTM], 1989, pp. 114–115).

Technological pedagogical content knowledge (TPACK) has emerged as a framework to describe teachers' knowledge for the integration of information and communications technology (ICT). It was extended from Shulman's (1986) effort to articulate teachers' unique professional knowledge.

Research Paper

Rycroft-Smith, Lucy*

University of Cambridge

Research summaries for mathematics teachers: materials that translate between theory, evidence, practice and praxis

Many researchers and educational policymakers recommend that mathematics teachers' practice be more research-informed (e.g. Coldwell et al., 2017; Sullivan, 2011) and that teachers engaging with research - particularly in a critical dialogue - would be of benefit to both researcher and practitioner communities. Yet often, mathematics education research appears to have had little impact in terms of policy, engagement or student attainment (Hodgen et al., 2010; Levin & Ji, 2011). The production of materials such as teacher-facing research summaries to support knowledge mobilisation has sought to bridge the gap, specifically in order to address barriers of accessibility and teachers being time-poor. This is a work-in-progress session which considers some of the issues in producing and communicating such research summaries ahead of collecting teacher and researcher evaluation data on them using the method of comparative judgement.

Research Paper

Sayers, Judy*; Petersson, Jöran; Rosenqvist, Eva; Andrews, Paul.

Leeds University, UK; Malmö University, Sweden; Stockholm University, Sweden; Stockholm University, Sweden.



Estimation: An inadequately operationalised national curriculum competence

Research over the last two decades has highlighted not only the importance of estimation as a life-skill but also the dearth of opportunities children experience to acquire it. Our ongoing analysis of the literature has tentatively identified four forms of estimation. Number line estimation concerns the placement of numbers on an empty number line. As highlighted in studies of both children's and adults' strategy choices, it is a strong predictor of both mathematical learning difficulties and mathematical achievement. Quantity estimation addresses the number of objects in a set and is closely tied to the ability to count. It is a skill required of many professionals. Computational estimation concerns the ability to make a reasonable prediction of the outcome of a calculation. In addition to being an important life skill it facilitates understanding of both place value and standard algorithms. Measurement estimation concerns the size of the various properties of objects. It is an important life skill, with many adults using it in their professional decision making. In this paper we compare how these four forms are manifested in the statutory expectations of the national curriculum to highlight a major omission in the educational experiences of English students.

Research Paper

Thoma, Athina * & Iannone, Paola*

University of East Anglia, Loughborough University

University students' proof writing and LEAN theorem prover: the case of the abundant number task

In this talk, we present results from a study investigating the potential impact of undergraduate mathematics students' engagement with an automated theorem prover (LEAN) on their proof production. The students were offered the opportunity to interact with LEAN in optional evening sessions throughout the first semester of the first year and were also shown the potential of this software in some of the lectures. The participants, whose experiences with LEAN varied, were interviewed at the end of the teaching period and were asked to prove seen and unseen mathematical tasks using a think-aloud protocol.

Here we focus on the proofs produced by thirty-six students on an unseen task. We first scored the proofs of both experienced and non-experienced LEAN. We then analysed qualitatively the proof writing alongside the interview transcripts following the Fukawa-Connelly (2012) framework. Results suggest that engagement with LEAN assists in making the proof-writing more rigorous; helps with the deployment and use of definitions in proofs; and with the syntax of proof writing. Finally, we will discuss challenges that prevented students from engaging with LEAN.

Research Paper

Tiflis, Ozdemir

Brunel University London

Using errors to identify teaching approaches for ratio and proportion problems

Although there are many difficulties encountered by students when learning the topic of ratio and proportion, this issue has not received sufficient support from mathematics education research. This study develops an understanding about errors made by re-sit GCSE students in England and vocational school students in Turkey when attempting ratio and proportion problems. It investigates the causes of these errors to provide detailed information about the difficulties that students encounter. For this purpose, an error analysis model and a diagnostic test are developed. Data were analysed using percentage and frequency descriptive statistics. It found that understanding errors, mathematisation errors and processing skills errors were the most common type of errors made in England, while although Turkish students' errors included understanding errors and mathematisation errors, they didn't make processing skills errors. The causes of all students' errors were based on them using inappropriate strategies, and their inability to reason proportionally. It is



suggested that the results of this study can be used in developing new teaching approaches to eliminate the difficulties experienced by the students in learning about ratio and proportion.

Research Paper

Wenderlich, Maja

Maria Grzegorzewska University, Warsaw, Poland

The Milestones in the Life Course of Distinguished Mathematicians and Mathematically Gifted Adolescents

The paper presents the results of research on milestones (significant events, critical points, crystallizing experiments) in the course of life of outstanding mathematicians and mathematically talented adolescents. The work covers a period of approximately the last 80 years. Four distinct groups of mathematicians had received their education and pursued their scientific careers at that time: late, distinguished professors of mathematics, distinguished professors of mathematics who are still alive, Ph.D. students and doctors of mathematical faculties, laureates of mathematical olympiads. The author's intention was to indicate milestones – key events and moments in their history determined by the author (or those indicated by the interested) to reach the highest position and recognition in the field of mathematics. Those are, for example, important experiences in a person's life that played a huge role in choosing mathematics as a direction for further development or reasserted that mathematics is the right choice. The considerations were based on a holistic, humanistic approach and a biographical approach from the perspective of Charlotte Bühler. The course of human life. The techniques that have been used include document analysis and narrative interviews. According to the recommendations of Bühler's results were presented graphically on the timelines.

Research Paper

Wong, Vicky*; Ingram, Jenni*

University of Oxford

Student teachers' understanding of randomness

There are numerous uses and definitions of randomness both in our everyday lives and in the research literature. The notion of randomness underpins the teaching of statistics, biology, chemistry and physics yet for many randomness is difficult to understand and define. This includes prospective mathematics and science teachers. In this session we will explore the similarities and differences in prospective mathematics teachers' and prospective science teachers' definitions of randomness and how these influence their responses to tasks commonly used in school mathematics or science classrooms.

Research Paper

Woollacott, Bethany*; Inglis, Matthew; Alcock, Lara

Loughborough University

A Level Students' Perceptions and Self-reported Use of their Mathematics Textbooks

How students read, and use, their mathematics textbooks has not been widely researched (see Fan, Zhu & Miao, 2013) and yet the limited findings that do exist suggest that tertiary-level students are not effective readers of their mathematics textbooks (Shepherd, Selden & Selden, 2012). Given the textbook's potential to enable independent learning, researchers have proposed that more research into how students are reading and using their textbooks at all levels is needed to inform practice and future research (Rezat, 2010; Selden & Shepherd, 2013). In my doctoral study, I have interviewed college-level students about how they report using their textbooks and their opinions about its features. My initial thematic analysis of transcripts of 23 student interviews has led to nearly 30 themes which I have begun to group into a smaller number of over-arching themes. In this session, I



will present my emerging analysis and invite participants to comment on the issues raised and suggest how these themes might be related and probed further.

Research Workshop

Working groups, one hour

Wright, Pete*

UCL Institute of Education

Critical Mathematics Education (CME) Working Group - discussion on 'What are the implications of Bourdieu's ideas for the mathematics classroom?'

The CME Working Group (launched in November 2015) is open to all and aims to promote research that brings about positive social change through mathematics education. CME aims to identify and challenge ways in which mathematics is commonly used to maintain the status quo and reproduce inequities in society. It proposes an alternative and empowering conceptualisation of mathematics, which enables people to better understand their social, political and economic situations, and to advocate and bring about changes leading to a more just and equitable society.

"Often with a psychological brutality that nothing can attenuate, the school institution lays down its final judgements and its verdicts, from which there is no appeal, ranking all students in a unique hierarchy of all forms of excellence, nowadays dominated by a single discipline, mathematics."

(Bourdieu, 1998, p. 28)

This is an opportunity to discuss how researchers, educators and teachers might draw on Bourdieu's ideas, including 'cultural capital', 'symbolic violence' and 'reflexive sociology', to inform their practice. Bring along your ideas to share or just come along to learn more about how Bourdieu's ideas might inform your practice.

Foster, Colin*; Wake, Geoff* & Baldry, Fay

Loughborough University, University of Nottingham, University of Leicester

Didactics working group

So far, this working group has examined some of the didactical approaches taken in various different textbooks and mathematics classroom resources. In particular, we are interested in how certain 'didactical devices' can support coherence within a curriculum, both between different topics and across different ages. In this session, we will seek to clarify what might be meant by a 'didactical device', and examine how this might relate to 'a model' or 'a representation'. We will attempt to identify useful features of didactical devices that could promote the kind of coherence that we believe is helpful within the curriculum, and we will consider how this might inform task design and curriculum design.

Ineson, Gwen*, Gifford, S*, Marks, Rachel*

Brunel University London, Roehampton University, University of Brighton

Early Years and Primary Mathematics (EYPM) Working Group – 8th meeting

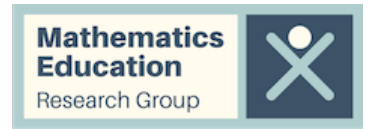
In this eighth meeting of the Early Years and Primary Mathematics (EYPM) Working Group, we will continue to build on the networks that have been developing within the group. We also welcome new members with an interest in EYPM – so you are warmly invited to join us.

During the session we will focus on the following:

1. The EEF have just published a report on Improving Mathematics in the Early Years and Key Stage 1. We will discuss the main findings and the implications of this for maths teaching and research in this age phase.
2. Possible research ideas to collaborate on between meetings. Many of us would welcome the



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opportunity to work with others on our research ideas and this seems to be an appropriate forum to collaborate on these. If you have an idea for some research activity that you would like some input/support on, please come along to share it.