British Society for Research into Learning Mathematics

BSRLM AUTUMN DAY CONFERENCE 2023

SESSION HANDBOOK

UNIVERSITY OF BRISTOL

Saturday 4th November, 2023

Plenary Presentation: Dr Nancy Barclay

Nancy Barclay is a principal lecturer in mathematics education at the University of Brighton. Nancy's research has primarily focused on the dynamics of classroom mathematics encompassing both the mathematical activity of primary children and the manifestation of authority relations in the primary mathematics classroom. Alongside colleagues from the University of Brighton, she has recently completed Nuffield funded research focusing on the use of curriculum resources, including textbooks, in primary mathematics.

Nancy won the Janet Duffin Award 2021, for 'Valid and valuable: lower attaining pupils' contributions to mixed attainment mathematics in primary schools', an article published in Research in Mathematics Education.

Valid and Valuable: lower attaining pupils' contributions to mixed attainment mathematics in primary schools

This session focuses on my research into the mathematical activity of mixed prior attainment pairs in primary mathematics classrooms, centring its attention on the mathematical contributions of the lower attaining child in each pair. Whilst such children are often seen as the recipients of help in mixed pairings this research sought to examine whether there was more to the relationship than this. Its focus on the lower attainer thus illuminated their mathematical contributions and how they influenced task progress for the pair. I will discuss the methodological approach and explain the construct of, and analytic challenges inherent in, the selected focus of mathematical noticing. Subsequently I will share some data drawn from the mathematical activity of two pairs of children in one of the tasks to illustrate the path to some of the inferences made and conclusions drawn. Some complexities and pedagogical challenges will also be explored.

Research papers, workshops and working groups

*[Where there are multiple authors, * Is used to identify presenters]*

Ahn, Aehee (University of Bristol) **[PRESENTATION]**

Dealing with mathematical uncertainty: Students' hedging actions in writing

Hedging, associated with uncertainty, serves as a shield to protect the users themselves from making errors by using vague language such as maybe, I think, and about. I conducted script writing with 27 primary students (aged 11-12) to explore their fractional understanding. I hypothesised that students who have less confidence in fractions or mathematics might use hedging words through student characters they created in their scripts. Except for 'I think', however, hedging language was rarely used in students' scripts. Instead, I observed that students showed a different form of hedging through the teacher characters students created, depending on the level of uncertainty of the prompts provided for their scripting. When the prompts had clear mathematical answers or dealt with relatively straightforward concepts within the students' reach, students provided confident and unambiguous explanations of fraction concepts through their teacher characters. However, when the prompts involved open-ended questions or more challenging concepts for students, the teacher characters in the scripts tended to adopt a more reserved approach and show reluctance to pass judgment. With the protective actions of the teacher characters, students managed their own mathematical vulnerability and kept a neutral position to protect themselves against potential errors and uncertainties in their understanding of fractions.

Asghari, Amir (Liverpool John Moores University) **[PRESENTATION]**

Women of Mathematics

I am reporting on the current outcome of an ongoing YouTube project called 'People and Mathematics,' in which Iranian men and women whose professional lives are closely tied to mathematics share the stories of how they became who they are today. The primary focus of the presentation is on the stories of women, with occasional comparisons to the stories of men. This provides a unique window into the recent history of Iran and the social life of Iranians through the eyes of individuals who share one common passion: their love for mathematics. I aim to address the intriguing question of why it was that the first female Fields Medallist, Maryam Mirzakhani, happened to be Iranian.

***Babbar, Sunita (Brunel University); *Ineson, Gwen (Brunel University)** **[PRESENTATION]**

"There isn't time for the 'why'": Secondary maths student-teachers' approaches to teaching calculation

This small-scale study of secondary maths student-teachers used a range of calculation problems, to discuss their preferred method for solving problems for themselves, and how they would support their pupils. Data gathered included written jottings of their calculations, their identified strategies to use in the classroom, and follow up interviews to expand on their approaches. Analysis used the I and S-Rationale framework (Herheim, 2023) to identify how student teachers' mathematical understanding influenced their proposed approach in their classrooms. Case studies are used to exemplify the range of responses to the problems. Results show that although student-teachers could draw on a range of approaches to support long division and multiplication of decimals, division of fractions prompted a procedural response for themselves and in their teaching. Participants suggested that this was due to the lack of time and space in the curriculum, indicating the time pressure teachers experience. Further time and space is needed to explore what might be possible for student teachers on a one-year PGCE programme, to build their confidence and understanding, to be able to teach for relational understanding.

***Baldry, Fay (University of Leicester); *Syyeda, Farhat (University of Leicester); *Harvey-Ashenhurst, Ben** **[PRESENTATION]**

Investigating the impact of 10 years of Maths Hubs: Negotiating the tensions between research finding and cause/effect connections sought by providers of professional development

This presentation is a part of a Knowledge Exchange project with a Maths Hub within the East Midlands. Maths Hubs are the major provider of professional development (PD) for teachers of mathematics having been funded by the government for ten years. The aim of the project is to develop an understanding about how the impact of Maths Hub activities could be evaluated. We focussed on NCETM Maths Mastery due to the pivotal role it plays in the hub activities. We will present our model of PD that draws on Guskey (2002) and Desimone (2009) models. Data was collected through semi-structured interviews, conducted face to face or online. Our key findings are that knowledge and understanding about Maths Mastery vary considerably, even among those with long standing and substantial involvement with the Maths Hub. For some their goal appeared to be achieving fidelity with the NCETM mantra, whereas for others, mastery was viewed as a 'pick and mix' situation where they could incorporate selected elements into their current practice. Assessing any PD is hard as there are so many factors involved. Providers sought concrete

links between PD courses and specific outcomes, which did not align well with the messiness and caveats involved in contingent finding that characterises research.

***Coles, Alf (University of Bristol); *Weber, Christof (School of Education Lucerne)** **[WORKSHOP]**

Mathematics Education and Sustainable Futures

How is climate change relevant to mathematics education? What does environmental justice mean for teaching and learning mathematics? What socio-ecological issues could be addressed in classrooms or in teacher education, and how? How might pedagogical practices support an awareness of choice in mathematics and, through awareness of choice, support listening, hearing and respect for others' ways of knowing? These are some of the questions we want to address in this workshop. Part of our purpose is to explore if there is energy to set up a BSRLM working group around such issues and, if so, to set an agenda for future sessions. We will begin with an overview of some current thinking about mathematics education and sustainable futures (recognising the contested nature of the term "sustainability") and we will outline some current international networks working on such issues. One argument we make is for the importance and relevance of choice, from a subject-related point of view, as a contribution mathematics education can make to sustainable futures. We will illustrate the role of choice with an example from the field of algorithmic thinking, where choices of strategy and choices about sequencing are key ideas. And from here we will open out to discussion.

Davies, Ben (University of Southampton) **[PRESENTATION]**

Bringing SMP into the 21st Century with STACK: Opportunities for Computer-Aided Assessment in Key Stage 5

This session will focus on a project developing interactive math workbooks for secondary school students using STACK. Four workbooks were trialed with approximately 400 students across four Hampshire schools in 2023. I will present a preliminary analysis of the feedback collected from students and teachers, and reflect on the challenges and opportunities of undertaking such a project. One important finding for further reflection centers on the quality and volume of feedback available in more traditional modes of instruction, and the opportunity for Computer-Aided Assessment to augment/support teachers in providing bespoke and immediate feedback on students' take-home tasks. Having received largely positive feedback from students and teachers, we find ourselves at a crossroads with this project and seek input from the community regarding next steps for this work.

***Iannone, Paola (University of Edinburgh), Thoma, Athina (University of Southampton)** **[PRESENTATION]**

Students' activity when using an Interactive Theorem Prover tool: The case of the Natural Number Game

Programming in university mathematics is generally linked to mathematical modelling and computational methods, or to statistics (Sangwin & O'Tolle, 2017), however interactive theorem provers (ITPs) are slowly starting to enter the classroom, especially to support first-year transition to proof modules. Participants of this study are four students who attended a transition to proof module in which Lean (https://leanprover-community.github.io), one of the most used ITPs in the UK, was introduced. They were interviewed while making their way through the levels of the Natural Number Game, (https://www.ma.imperial.ac.uk/~buzzard/xena/natural_number_game/), a resource created to teach undergraduate students to use Lean. Focus of the research is the analysis of the interaction between the students and the tool (the ITP) seen through the lenses of instrumentation (Trouche, 2014). In order to analyse this interaction, we propose an operationalisation of the components of students' schemes (as in Vergnaud, 1996) into a coding system and we present some preliminary results in terms of the actions that students employ when going through the different levels of the game.

***Ingram, Jenni (University of Oxford); *Lee, Gabriel (University of Oxford)** **[PRESENTATION]**

Always, sometimes, or never true? The linguistic challenges of transition between examples and generalisations

Language plays an important role in promoting learning in mathematics. Research has indicated that mathematics classrooms are linguistically diverse, and many are multilingual. Both students and teachers can experience a wide range of linguistic challenges to varying degrees. Identifying linguistic challenges and enhancing language can therefore promote students' learning in mathematics. This research presentation reports on the analysis of video excerpts from three classrooms in England focusing on a task on linear equations. The task is well known by many teachers in England and is adapted in a design-based research project that explores opportunities and develops language-responsive materials to support learning and teaching mathematics. In the task, pupils were asked to determine and explain whether some linear equations, such as $x + y = xy$, are always, sometimes, or never true. This presentation will focus on the first iteration of the use of language-responsive materials surrounding the task and discuss the complex relationship between examples and generalities within mathematics.

Jacques, Laurie (UCL Institute of Education) **[WORKSHOP]**

Pedagogical practices to promote pupils' mathematical learning from one-problem-multiple-changes procedural variation tasks

The inclusion of deliberate variation and invariance in mathematical tasks is widely accepted as a useful means of designing experiences that can lead to pupil learning. Despite a growing body of research focusing on the content of textbooks, lessons and tasks designed with attention to variation and invariance, less is known about the accompanying pedagogical practices employed by teachers to promote pupils' mathematical learning, particularly in the Chinese tradition of variation pedagogy (Bianshi). In a recent study in England, eight primary teachers collaborated to design one-problem-multiple-changes procedural variation (OPMC PV) tasks with which to promote pupils' mathematical learning. Qualitative content analysis of the work of the teachers during an iterative form of lesson study, framed by the principles of procedural variation (anchoring points of knowledge, pudian, potential distance and bringing convergence), were used to characterise the pedagogical practices accompanying the tasks. This revealed three procedural variation-specific pedagogical practices: promoting a shared language, using navigational signposts to guide the pupils' work on the tasks and presenting the equations such they could be worked on in two dimensions – horizontally and vertically.

Ji, Yuan (University of Bristol) **[PRESENTATION]**

Teaching and learning early algebraic equations in a Chinese classroom: A design-based research study grounded by The Theory of Objectification

The presence of a procedural meaning of the equal sign and procedural understandings of equations reported in previous research calls for suitable interventions in teaching and learning equations. The aim of this research is to investigate the explicit features of interventions that address equation solving in Chinese early algebraic classrooms, and the emergence of procedural and relational understanding in children's learning process. In this pilot study, a designed-based research was conducted, based on teaching-learning activity guided by the theory of objectification of Luis Radford. A classroom instruction was designed, transposed and implemented in practice under the close collaboration with a local teacher. The analysis on video recordings of classroom episodes have revealed some explicit features of both Davydov's curriculum and variation theory, the separation between the preliminary designed instruction and the modification by the teacher has also called for a better culture combination of Chinese curriculum with the theory of objectification.

***Jones, Ian (Loughborough University); *Makri, Depy; *Kontorovich, Igor'; Obiero, Michael; Zevick, Juma; Hooper, Curtis** **[PRESENTATION]**

Is writing automated tailored feedback worth the effort?

On university modules with large cohorts technology can be used to provide immediate feedback on students' mathematical answers. Sophisticated systems such as 'STACK' can be programmed to detect common or known student mathematical errors, and so provide feedback tailored to those errors. However, programming tailored feedback is time-consuming and given the mixed results of the feedback literature might not be worth the effort. We conducted an experiment in which students attempted questions that targeted a widely-reported misconception involving calculating the area bounded by a curve and the x-axis. The students were randomised to one of three conditions: no feedback, accuracy feedback ("Correct answer, well done" or "Incorrect answer"), or accuracy-with-elaboration feedback ("Incorrect answer. Here is a graph of the function. The total area between the x-axis and the function is given by the sum of the areas above and below the x-axis"). As expected most students scored poorly on the problems. The students received feedback (or not) according to condition, and then attempted a post-test. Against our expectations most students across conditions scored 0 in the post-test, although a slightly higher proportion of those in the accuracy-with-elaboration feedback condition scored >0 than those in the other conditions. We suspect that programming automated tailored feedback that responds to common misconceptions in university mathematics may not always be worth the effort.

***Joubert, Marie (University of Nottingham); *Gripton, Cath (University of Nottingham); *Corpe, Alicia (Goodway Nursery School, Birmingham)** **[PRESENTATION]**

Using the Counting Collections approach with pre-school children: emerging findings from a development project

In this ongoing study, eleven preschool practitioners are using a counting collections approach, which involves a four-part routine: choosing a set of objects to count, planning how to count the objects, counting them and recording their counting. Practitioners have been provided with 50 plastic boxes containing objects for children to count and a set of 'tools' such pots, numerals and five frames which can be used to help with counting (together these make up the Counting Collections 'library'). The practitioners attend five professional development sessions, two of which have taken place to date. The professional development aims not only to help practitioners understand the four-part routine, but also to develop subject knowledge, an understanding of learning trajectories and confidence in teaching early number. The research involves surveying all participants and setting leaders as well as interviewing and observing five 'case study' practitioners. Data from initial visits to case study settings has been gathered and analysed. We report on our initial findings in two main areas: 1) the ways in which the practitioners and children have used the Counting

Collections library and routine and 2) the practitioners' reflections on their professional learning.

Kinnear, George (University of Edinburgh) **[PRESENTATION]**

Longitudinal insights from validation of the Mathematics Attitudes and Perceptions Survey

The Mathematics Attitudes and Perceptions Survey (MAPS) was developed as a tool to measure undergraduate students' attitudes toward mathematics. I will present analysis of responses to MAPS (N=3145), gathered from first-year students over three consecutive academic years at the University of Edinburgh. The survey was administered twice each year, to investigate changes in students' attitudes throughout their first semester at university. The three years of data collection overlapped with the Covid-19 pandemic, so the responses also shed light on possible changes in attitudes during this period. The outcomes highlight the potential for wider use of MAPS in research, as a tool for measuring, tracking, and comparing students' attitudes toward mathematics.

Kontorovich, Igor' (University of Auckland) **[PRESENTATION]**

Transitioning to proof via writing scripts on the rules of a new discourse

Using the commognitive theory, we consider proof-based mathematics as a distinct discourse, the transition to which requires special rules for endorsement of statements. We investigate newcomers' learning of these rules when being taught them explicitly. Our data come from academically motivated high-school students who took a special undergraduate course. The lecturer dedicated 3 academic hours to introducing selected rules of proof to support students' shift to the new discourse. The homework consisted of typical proof-requiring problems and a scriptwriting task, asking students to compose a dialogue between fictional characters about some proof-related mistake. We analyzed the differences and similarities between the rules discussed in the classroom and those that students raised and employed in their proofs. The analysis showed that while students' solutions to proof-requiring problems required rule implementation, fictitious dialogues included rule formulation and substantiation. In many cases, the students discussed the classroom rules, extending, elaborating, and specifying the teacher's formulations. Furthermore, while the students' proofs were mostly consistent with the teacher's expectations, some of their rule formulations were more radical and overgeneralized than expected. These findings suggest that newcomers' communication about the rules of proof may lag behind their implementation of those rules to prove mathematical statements.

***Lee, Stephen (MEI); Tripconey, Sharon** **[PRESENTATION]**

The impact, in teachers own words, of sustained mathematics professional development 18-months on – findings from a large-scale survey

During the Summer term of 2023, an extensive online survey was sent to 900 secondary school teachers who had completed an Advanced Mathematics Support Programme sustained professional development course in 2021-22, to understand any impact it may have had 18-months on. This presentation will detail the survey creation, which included a collection of specific open-ended questions, as well as some benchmarking question sets. It will discuss the feedback from almost 200 teachers who completed the survey. Impact on teacher's own classroom practice, on their students and their wider department/school will all be reflected upon. Aspects of Ofsted's 2023 independent review of teachers' professional development in schools report will be considered against the responses from mathematics teachers who completed the AMSP survey.

***Lord, Emms (NRICH, University of Cambridge); Nosrati, Mona** **[PRESENTATION]**

ChatGPT in the mathematics classroom: Enhancing problem-solving skills through AI

Widespread access to new technology has inevitably led to debate regarding its role in the mathematics classroom. Devices such as calculators and mobile phones tend to be restricted to specific areas of mathematical study; especially number, graphs and algebraic problem-solving. More recently, ChatGPT has offered the opportunity to explore solving a greater range of mathematical problems using AI. This session will present some initial findings from a research project which forms part of a wider ongoing collaboration between Mattelist (Norway) and NRICH (England). The presentation will explore problem-solving solutions written by students with those generated by ChatGPT, and discuss possible implications for classroom practice regarding the development of problem-solving skills.

Lyakhova, Sofya (Swansea University) **[PRESENTATION]**

Technology in HEI teaching and assessment

The study focuses on examples of the use of technology in mathematics teaching in the UK universities. While universities are very different from schools in how much freedom they could exercise over their own curriculum and assessment system, we take a view that HEI experience may be useful, in a broad sense, when undertaking implementation of

technology at any stage of education. The four case studies presented include modern teaching focused universities and traditional research universities covering a diverse range of student cohorts and degree courses varying from pure mathematics to applied mathematics and statistics. The study has been conducted to support the work of the JMC Digital Technologies and Mathematics Education Working Group.

Machino, Natheaniel (University of East Anglia) **[PRESENTATION]**

Addressing mathematics student teacher needs in further education through mentoring

Mentoring has become established as a central feature of initial teacher education programmes in the further education and training sector, yet there remains lack of clarity within the sector about how mentoring should address student teacher needs. Therefore, an empirically based mentoring model on how mentoring should assist the development of mathematics student teachers' mathematical and pedagogical knowledge by addressing the student teacher needs has to be developed. In this presentation, I report findings of the analysis of data collected through interviewing mentors and student teachers, observing mentor meetings and self-administered anonymous questionnaire completed by mentors. In an attempt to capture participants' views on how mentoring assists the development of mathematics student teachers' mathematical and pedagogical knowledge by addressing the student teacher needs, thematic analysis is employed as the analytic tool. I exemplify the five themes from the data: assisting in teaching specific topics; getting influence of experienced teachers; discussing general issues in teaching mathematics; assisting in working through mathematics questions; and promoting accurate teaching of mathematics. These themes are seen as having the potential of assisting the development of mathematics student teachers' mathematical and pedagogical knowledge by addressing the student teacher needs. Keywords: Student teacher needs; mathematical and pedagogical knowledge.

Morris, Hannah (University of Bristol) **[PRESENTATION]**

Visualiser, Whiteboard or PowerPoint - the impact of modelling mathematics using different modalities on the accuracy of student work

As a practicing secondary mathematics teacher, I observed anecdotal evidence that the modality chosen by mathematics teachers when presenting examples seemed to impact student participation and accuracy in example-problem pair work, where students are expected to copy an example and then complete a similar 'my turn' problem. This research was designed to systematically review student work and identify any trends when I modelled examples using PowerPoint slides, a whiteboard, and a visualiser. Data suggests participation is consistent across the three modalities, but accuracy varies. The visualiser

seems to ensure the most accuracy across multiple metrics. Findings also suggest the potential for significant impact on the experience of SEND students in particular. In this session, I will present my findings, provide opportunity to experience each modality, share the original data for further analysis and host a discussion about the best direction of my ongoing research.

Oktay, Omer (Brunel University) **[PRESENTATION]** 

Digital game-based learning for formative assessment in primary school mathematics education

My PhD research explored how primary school teachers in England view and utilise digital game-based learning (DGBL) in maths education and how formative assessment frameworks can be applied to their DGBL approaches. In this regard, I followed Black and William's (2009) five key strategies for effective formative assessment and Burkhardt and Schoenfeld's (2018, 2019) teaching for robust understanding (TRU) framework that proposes 5 dimensions of an effective maths lesson. Within a mixed-method design, I surveyed 60 teachers and interviewed 10. Results revealed that although teachers view DGBL as effective in increasing motivation, enjoyment, engagement, and academic achievement in maths, they only utilise simple, practice-based games that aim to increase students' procedural fluency rather than higher-order skills such as conceptual understanding, strategic competence, or adaptive reasoning. Regarding formative assessment, results showed that how teachers use DGBL in maths lessons does not meet either all five key strategies that Black and William (2009) suggest or all five dimensions that Burkhardt and Schoenfeld (2018, 2019) propose. Findings indicated that teachers do not see DGBL as suitable for strategies such as clarifying and sharing learning intentions, engineering effective classroom discussions, providing effective feedback, and equitable access to mathematics. Keywords: Digital Game-Based Learning, Formative Assessment, Mathematics Education, Teachers' Perspectives.

Papadaki, Evi (University of East Anglia) **[PRESENTATION]** 

Exploring the characteristics and challenges of discussions beyond the Mathematics of the Moment: Discussing definitions and proofs in Year 7

The presentation reports on an exploratory study of opportunities for discussion about mathematical ideas and practices beyond the boundaries of the curriculum in Secondary School. The study took place in the East of England and participants are 3 Secondary School Mathematics teachers and their students, 60 in total. Drawing upon the theory of Commognition (Sfard, 2008), I will first present the analytical approach and methods for identifying and studying the communicational patterns between a teacher and the students. The qualitative analysis of data from 16 lesson observations and interviews with the

teachers highlighted unique communicational patterns in discussions beyond the boundaries of the curriculum. To illustrate the contribution of the study, I focus on two key episodes which took place during lessons of one teacher with her top-set Year 7 students. The first episode exemplifies teachers' and students' attempts to build a shared discourse to work and communicate mathematically beyond the curriculum requirements. While the second emphasises the challenges teachers encounter when inviting students into uncharted for them mathematical territories.

Peters, Adam (University of Exeter) **[PRESENTATION]**

Towards a framework for Coherence

East-Asian countries continue to outperform Western countries participating in the TIMSS study for mathematics outcomes (IAEEA, 2020). Despite the increasing trend of pupils attaining higher levels of achievement, the UK remains behind their East-Asian counterparts in the pursuit of improving mathematics education outcomes. The teaching of mathematics in England has been heavily scrutinised, with the government drawing on practice from Singapore and Shanghai. Amongst these practices, lies the idea of 'Coherence'. Despite an agreement that coherence is important for curricular alignment (Schmidt et al, 2002), its multi-faceted nature requires the term itself to be further delineated. In addition to this, the NCETM (2020) define coherence as lessons consisting of 'small, connected steps' which 'gradually unfold a concept'. As a result, teachers in England may interpret coherence as an end point that can be achieved through lesson planning and delivery, however this falls at odds with trends within the literature (Honig and Hatch, 2004). Based on a review of the literature, this presentation will consider the distinctions in terminology surrounding the term coherence as well as consider a framework for which coherence can be observed throughout the instructional process. Ideas for how a teacher's beliefs of their own coherence play out within their actual practice will also be considered with the aim to provide a framework for anticipating coherence within the classroom.

Reid-Jones, Gavin (University of Leicester) **[PRESENTATION]**

The Confidence Attainment Cycle

This presentation explores a conceptual framework of a possible cyclical relationship of the nature of a students' mathematical attainment and their confidence as a mathematician. Complex and layered, confidence is an intricate part in the interactions that take place every day in a classroom and has a key link to the way in which students attain within mathematics. In the review of existing literature, I have developed a model highlighting this relationship and its potential cyclical nature. Drawing on the models of Self-Efficacy proposed by Bandura (1977), and Self-Concept proposed by Shavelson, Hubner and Stanton (1976) I have developed a definition for confidence that allows for the relationship with

attainment in the context of mathematics classrooms to be explored. Here, I will discuss this conceptualisation of confidence and the relationship with an individual's attainment through the lens of effective ways of working, and the potential of this theoretical framing to contribute to understanding mathematics classrooms. Further questions, such as how I intend to test the veracity of this model, will also be raised.

Rostill, Holly (Gordano School) **[PRESENTATION]**

How can mathematical tasks support children's confidence and motivation, particularly in mixed prior attainment groupings?

Teaching students with low confidence and motivation in mathematics can be challenging. I teach mathematics in a secondary school where students are being grouped based on a wider range of prior attainment (including Key Stage 4 classes) than has previously been the case. Some of my students report that they "cannot do maths" but I believe they have not yet experienced enough joy in their mathematics classrooms. One way to consider my teaching practice in relation to these challenges has been through a focus on task design and by exploring the elements of mathematical tasks that can help support students' confidence and motivation. In this study, students were asked to evaluate two mathematics tasks based on a theoretical framework of design elements to help to improve students' confidence and motivation. Eight students took part from a cross-section of prior attainment. In this session, we will explore what elements of mathematical tasks could help to improve students' confidence and motivation. I will present the theoretical framework from the initial study before working on the mathematics tasks, looking at extracts of the data collected from the study and discussing results.

Rumbelow, Michael (University of Bristol) **[WORKSHOP]**

Blockplay.ai - developing an app that uses AI to recognise and respond to placements of blocks on a tabletop

In this workshop I present a newly launched, free-to-download, prototype app which uses AI computer vision algorithms to recognise via a webcam, in near-real-time, the placements of multilink cubes or Cuisenaire rods on a tabletop. The app can then respond by generating images and soundfiles, such as speaking and displaying the number of cubes, their colours, or tones proportional to their length. After briefly demonstrating the app and reviewing some of the insights gained from iterations of user-centred design and testing, I invite participants to play with the app and discuss any potential future directions for its development, and some questions it raises about the opportunities and challenges of the use of AI in educational research. Some background information about the app, and information on how to download and use it, is available via the project website blockplay.ai. The app development was funded by the BDFI, JGI and Runway programme at the University of Bristol.

***Smith, Cathy (Open University); *Kathotia, Vinay (Open University); *Ward-Penny, Robert (Open University)** **[PRESENTATION]**

Crossing the boundaries of mathematics, statistics, data science and computing

How will children in 2035 be working with mathematics and data in schools? How should they be? The Royal Society recently commissioned an OU team to investigate the opportunities and challenges of integrating mathematics, statistics, data science and computing in the school curriculum. In this session we will introduce our analysis of the vision literature and reports from educational projects and jurisdictions already attempting such connections. Examining the intersections of these four subject landscapes has revealed concepts (such as 'certainty') that align more or less well across their boundaries; we hope for discussion of these concepts.

***Thoma, Athina (University of Southampton); Iannone, Paola (University of Edinburgh)** **[PRESENTATION]**

"The cost of mistake is nothing" - Exploring student's interactions with errors in an interactive theorem prover

Interactive theorem provers, which have been used in mathematics research for decades, are now starting to gain traction in university mathematics teaching either as integrated module components or as optional enrichment opportunities. Given this emergent integration, along with existing calls to explore connections between programming and mathematics (Lockwood & Mørken, 2021), the present work investigates students' coding activities within interactive theorem provers. More specifically, drawing on video data from a broader study, the focus of this talk is on one undergraduate mathematics student's activity when engaging with the Natural Number Game, a resource designed to introduce Lean – an interactive theorem prover. Using an instrumental approach, the student's interactions with error messages while proving a statement are analysed by identifying the rules governing his activity. We present our analysis and also explore implications regarding the links between mathematics and programming.

***Wong, Victoria (University of Exeter); *Fujito, Taro (University of Exeter)** **[PRESENTATION]**

Researching students' use of mathematics in science using a commognitive approach

While there is an increasing body of research which demonstrates that many students struggle to use mathematics within science, there has been little research on how students make sense of mathematics within science. We examined patterns in students' discourse to identify different approaches used by students in collaboratively solving quantitative science

problems. We gave small groups of undergraduate bioscience (n=6) and 15-16 year olds school students (n=15) a series of quantitative science problems and video and audio recorded their responses. We analysed the data using a commognitive approach, focusing on word use, visual mediators, narrative and routines. We identified four patterns in the discourse as students solved quantitative problems: science-dominant reasoning; equation-searching; mathematics-dominant reasoning and use of a schema. We found that all four patterns could lead to successful problem solving and suggest that encouraging students to discuss their ideas while answering such questions can open them up to different ways of thinking and reasoning. We further argue that using such a commognitive approach has great potential for researching how students make sense of mathematics within science.

Wright, Pete (University of Dundee) **[WORKING GROUP]**

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

This is an opportunity to discuss how researchers, educators and teachers might draw on Freire's ideas, including 'praxis', 'conscientization', 'reading and writing the world' and 'critical pedagogy', to inform their practice. Bring along your ideas to share or just come along to learn more about how Freire's ideas might inform your practice. Attendance is optional, of course, but remember that "washing one's hands of the conflict between the powerful and the powerless means to side with the powerful, not to be neutral" (Freire, 1985). 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. Freire, Paulo (1985). The Politics of Education: Culture, Power and Liberation. Bloomsbury

***Yeung, Sze-Man (University of Exeter); Fujito, Taro** **[PRESENTATION]**

A critical realist exploration of mathematical thinking and its impact on deep procedural learning through productive practice

Mathematical thinking is critical for generating insights or ideas generated while doing tasks. It is an essential mechanism for the progression towards advanced mathematical understanding. This study delves into the "real but unobservable" mechanism – mathematical thinking and its impact on deep procedural learning, including the acquisition of the cognitive understanding of the computational process and the ability to flexibly select appropriate strategies. Taking the view of critical realism, we explore the interplay between

underlying mechanisms and inherent causal powers of entities to comprehensively explain the development of deep procedural understanding. By conducting a series of 4 lessons in a small class setting with well-designed productive practices via video conferencing, we collected qualitative data on students' actions and explanations. Two students' internal casual powers: reasoning styles and risk appetites have been identified. This presentation will discuss the complex interplay between mathematical thinking and these internal causal powers to show how this shapes their deep procedural understanding through productive practices.

Zhang, Chengkang (University College of London) **[PRESENTATION]** 

Exploring the design principles of examples to help primary school students' multiplication learning

This study aims to find a set of principles for designing examples, which could be used as theoretical guidance or practical tools in mathematics education to help educators develop teaching materials or teachers organise their lessons. I use variation theory as the theoretical basis to explain learning, choose multiplication as the context topic in mathematics education, and apply design research to generate a set of design principles. I collect data through interventions with groups of three students and apply multimodal analysis to analyse data. So far, I have completed the theoretical stage (interaction 0), tested and improved (iteration 1 and iteration 2) the part of the design principles I proposed. This study is currently working on iteration 3.