BSRLM Abstracts, University of Manchester, 3 March 2012

Janet Duffin Lecture

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Using realistic artefacts to promote mathematics sense making: A framework for monitoring engagement

This presentation considers the nature and role of using realistic artefacts to promote mathematics sense making. The first part of the presentation outlines the opportunities afforded to children when solving an open-ended task that promoted number, measurement and spatial sense. The task encouraged student to personalise the problem-solving context and make decisions as they strategised and reached goals. The realistic nature of the task was established by using authentic artefacts that were critical for solution generation. The second component describes a related task given to the students within six months, this time in a cooperative problem-solving environment. Despite the previous scaffolded learning experiences, students found the activity both challenging and problematic, partially since the personalised context created multiple pathways and solutions options. A theoretical framework used to analyse the group dynamics highlighted both successful and unsuccessful interactions among members of the respective groups as they made sense of the tasks. From a classroom perspective, this study highlighted that teachers should be mindful of creating realistic scenarios that unintentionally interfere with the already demanding responsibilities group members have in balancing one another's ideas and approaches to solving open-ended tasks.
Nevertheless, those groups able to manage the sophisticated interplay between realistic solutions and group goal setting tended to manage group dynamics by weaving one another's interactions into the conversations by revisiting ideas rather than being overly influenced by dominant individual's ideas and approaches.

Research presentations

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The relationship between Saudi primary mathematics prospective teachers' subject matter and pedagogical content knowledge: handling student contributions in a lesson on Zakat

This ongoing doctoral study focuses on case studies of trainee mathematics teachers who are practising in six primary schools in grades four, five and six (10, 11 and 12 year olds) in the city of Arrass in Saudi Arabia. The main goal is to identify and explore the relationship between teachers' subject matter and pedagogical content knowledge and how teachers deal with students' contributions in Saudi classrooms. Two main instruments, observations and interviews, are used to gather data. The teachers are observed and videotaped while they are teaching in order to identify how they deal with students' contributions. This is followed by individual face-to-face semi-structured post-class interviews in order to discuss selected episodes from the lessons and thus delve further into the teachers' rationales for their actions. To explore teacher perspectives further during the interviews teachers are also asked to engage with hypothetical tasks (scenarios), based on previous studies of teachers' knowledge. Supplementary data towards building the teacher case studies will also come from student interviews and samples of teachers' responses to student coursework. In this session we will invite discussion on one episode from the study's pilot phase: a lesson on Zakat, the Saudi custom of donating a percentage of one's wealth to the poor. We will then share preliminary analyses of the episode informed by Rowland and colleagues' Knowledge Quartet as well as discursive approaches to analysing classroom interaction such as Sfard and colleagues' Focal and Preoccupational Analysis.

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Problem-Solving in Undergraduate Mathematics
The HE Mathematics Curriculum Summit took place at the University of Birmingham in January 2011, operated by the Maths, Stats and OR (MSOR) Network as part of the Mathematical Sciences HE Curriculum Innovation Project within the National HE STEM Programme. The summit culminated in the third call for funding to address the priorities that had been identified. One such priority was to collect and share good practice on problem-solving and to develop a bank of problems for use in effective problem-solving activities.
Coventry University and the University of Birmingham have surveyed problem-solving teaching in mathematics departments in universities in England and Wales, and are and are working closely with a number of departments with in order to develop more detailed case studies. The result of this work will be a guide to inform the implementation of problem-solving in undergraduate mathematics. Liverpool Hope University and NRICH, University of Cambridge are developing a a collection of interactive resources together with a collection of related problems suitable for a range of undergraduate mathematics courses. We report on early evidence from the survey of universities on the use of problem-solving in undergraduate mathematics courses and demonstrate an interactive starting point for problem-solving.

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Undergraduate Students' Reactions and Approaches to Example Generation Exercises
As part of a project exploring the design and use of mathematical tasks to promote conceptual understanding of calculus concepts, first year undergraduate students were assigned homework problems which required them to use various processes including generalising, conjecturing, evaluating statements, analysing reasoning and generating examples. In subsequent interviews with five students, a number of them spontaneously referred to the example generation problems posed as being the "backwards ones" or requiring them to work backwards as well as forwards. We report on the students' reactions to a particular example generation exercise, the strategies they adopt in an effort to solve such problems, and what they feel they learn in the process.

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Exploring the relationships between argumentation and reasoning: designing tools for the analysis of classroom conversation
I report on the tools I developed to analyse the mathematical reasoning and argumentation of some previously low-attaining Y11 students engaged in classroom conversation.
Reasoning is not a focus of the curriculum for students working towards the lower grades of foundation level GCSE. Consistent with this, the opportunities to work on mathematics afforded to the students I studied in their ordinary mathematics lessons tended to be short-answer questions on repeated examples. Perhaps unsurprisingly, much of the classroom argumentation was repetitive.
This raises a methodological issue about the interpretation of students' argumentation as reasoning. From a discussion of this issue, I explicate the research decisions underpinning attribution of deductive and transformational reasoning to some of the students in the group.

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What do teachers need in order to ensure that students in English schools master mathematics?
Whilst many teachers and school leaders believe that every child can succeed in mathematics, standards of mathematics achievement in English schools are variable and comparatively low. The fragmentary nature of the Frameworks has resulted in teachers 'covering' concepts quickly and repeatedly, leaving some students with only partial understanding. An emphasis on differentiation has reinforced the expectation that there will be a wide spectrum of student achievement, and that lower attaining students can only 'keep up' if the progress of higher attainers is constrained.
I will give a brief overview of the collaborative work by teachers in the ARK network of schools to address these issues, through the development of a research and evidence-based curriculum and pedagogic approach based on the curricula principles of Singapore.

I will also seek input from participants on how best to support classroom practitioners in transforming their practice. We are seeking to develop a lesson-planning tool that embeds on-going professional development and research findings. We are trying to avoid the twin risks of offering lesson plans and packages that leave teachers constrained by a model that they are implementing without understanding, and of offering research findings to teachers that are too vague or too time-consuming to implement into daily practice.

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Do subject specialists produce more useful feedback than non-specialists when observing mathematics lessons?
Schools and Ofsted often use non-specialists to observe mathematics lessons for accountability and professional development purposes. However, little if any empirical work has been conducted to investigate how well non-specialists observe mathematics lessons. We will present two studies in which experts made judgements about eight mathematics lesson observation reports produced by specialists and non-specialists. In Study 1, we found that twelve general education experts were able to recognise which reports had been produced by specialists and which by non-specialists. In Study 2, we found that eight mathematics education experts, who were not informed some reports had been produced by non-specialists, considered the specialists' reports to be more useful than the non-specialists' reports in terms of providing feedback to the observed teachers. We conclude that mathematics lessons are better observed by subject specialists where a goal is to provide the observed teachers with constructive feedback that can help improve their practice.

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'You weren't expected to be creative': policy-practice tensions
A new secondary curriculum was phased in from September 2007, with renewed emphasis on mathematical processes and applications and incorporating functional skills, as a response to the failure to fully implement the 'process' aspects of the 1999 curriculum (Smith, 2004).
The new curriculum is the basis for GCSE 2010 (single and linked pair), both with first large-scale certification Summer 2012. It is expected that assessments will include more multi-step, unstructured questions and more genuine problems.
I report on an on-going study to illuminate the relationship between policy and implementation of GCSE 2010, by exploring the beliefs and departmental-level context of two teachers in one department. The analysis draws on both Spillane's (1999) and Ball et al's (2011) approach to policy implementation. Both the department and the two teachers were well-placed to implement the reform, and believed they were doing so, yet after a year significant deviations from intended enaction were sometimes observed. I will reflect on the constraints and affordances of large-scale policy imposition.

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Investigations of Motivation and Engagement in Mathematics with Vocational Students
Case studies have been carried out with groups of Engineering and Construction students at a Further Education College in Wales.
Mathematical topics were introduced through the investigation of real world problems. Techniques required to solve the tasks were identified by the students themselves, and researched with the assistance of the tutor in an advisory role. Methods of Critical Thinking were developed by the students, and applied to the precise definition of the problems and the planning of effective solutions.
Activities which are examined include:

- Practical building site surveying
- Analysis of electrical properties of electronic circuits
- Use of networks in route planning, and in scheduling work activities
- Solid shape operations in computer aided design
- Motion of mechanical systems

Students' evolving views of mathematics, and accounts of personal motivation and engagement, were collected through interviews using a Conversation Analysis approach. Of particular interest were

accounts of the relative roles of experimentation, reflection and pedagogic learning in developing confidence and independence in the use of mathematical techniques.

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The multi-part lesson structure and the implications for attainment and assessment
The structure of primary mathematics lessons has remained largely unchanged since the introduction of the National Numeracy Strategy in 1998. Although the renewed framework for mathematics (2006) sought to release teachers from some of the constraints of the National Numeracy Strategy, many teachers continue to deliver their daily mathematics lesson in three parts.
I will introduce a multi-segment lesson structure developed during the academic year 2010/11. The clear developmental sequence of short 'chunks' leads to more advanced and complex learning within each lesson. This lesson structure promotes effective assessment for learning through a series of mini-plenaries. This approach has implications for language development, behaviour, concentration and deeper mathematical understanding. The lesson structure is now implemented across the primary phase in my school and has been disseminated successfully across the Ark Schools primary network. It is a key feature of the Mathematics Mastery approach developed by Ark Schools, which will be introduced into over 100 schools nationwide over the next two years.

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The mathematics in children's out-of-school economic activity
We report a study designed to investigate the nature of children's out-of-school economic activities, with a focus on the mathematical thinking that these involve. Children in Year 5 (9-10 years old) and Year 8 (12-13 years old), with a range of achievement levels in mathematics, participated in a series of activities over two weeks which involved the documentation of out-of-school activities. These included the completion of a structured diary, a photo-taking activity, and a questionnaire for parents to complete. Groups of three to four children were then interviewed in order to understand and explore the activities represented in these documents. We will present two main findings from our ongoing analysis. The first is that children are engaged in a rich range of mathematical practices – we will present some examples of these. The second is related to differences in the language that children use to talk about out-of-school mathematics and classroom mathematics, and ways in which these differences appear to play a role in inhibiting children's ability to mathematise aspects of their lives outside of school. Finally, we will discuss ways in which we plan to develop future classroom activities on the basis of this research.

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"I could have done better with like a positive atmosphere': secondary students' mathematical dispositions
This paper presents initial findings from an ongoing ESRC funded study of teaching and learning secondary mathematics in UK (www.teleprism.com). The substantive aim of this study is to understand (i) how learners' dispositions to study mathematics develop through secondary school, (ii) how mathematics pedagogies vary across different situations and contexts and (iii) how these pedagogies influence learning outcomes. This presentation focuses particularly on students' current dispositions and attitudes to mathematics in relation to their earlier pedagogic experiences and school pedagogic practices.
We will initially draw on quantitative findings from the first data point of our ongoing longitudinal survey of students in Year 7 to 11 (N=10,000+) to present the current state of students' dispositions as well as their perceptions of the teaching they receive.
We will then focus on qualitative data from interviews with students in one case study school in the North West. More specifically, we draw on 49 semi-structured interviews conducted with secondary school students, across all year groups (Year 7 to Year 11). Interviews focused on students' educational background, pedagogic experiences, attitudes and preferences, and future aspirations. The analysis focuses on how students relate their earlier experiences in mathematics education to their various attitudes and to their current dispositions. It aims to unravel several potentially key factors about the relationships between students' past experiences in mathematics, especially related to its teaching, and

their current dispositions towards it. It is assumed that these relationships are complex. The results presented here are preliminary and our aim is to devise a useful framework for future analysis of longitudinal data. We will finally discuss the implications of these findings for mathematics education.

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Modelling as a driver for the Level 3 curriculum
This is one of a series of papers proposing reform of the Level-3 mathematics curriculum. The potential advantages of substituting mathematical modelling for traditional applied mathematics were surveyed previously. It seems that these advantages, at least potentially, include: improved ability of the A-in-GCSE sub-cohort to use their mathematics; accessibility of Level 3 mathematics to the B/C-in-GCSE sub-cohort; the possibility that modelling insights (eureka moments) may enthuse learners about mathematics; the cross-curricula significance of mathematics - specifically an appreciation of the contribution of modelling to scientific knowledge and design processes. In this paper the telescope is reversed. Instead of looking at how the take-up and application of the traditional mathematics curriculum can benefit from introducing modelling into the classroom, I take a modelling viewpoint and ask how the curriculum's fitness for twenty-first century purposes might be improved by a modelling driven approach. My starting point is the recently published Case Studies: Real-World Problems for Secondary School Mathematics Students. I survey the contents from the viewpoint of the range of mathematics accessible to students for modelling topical real-world situations and issues such as: space-travel, growth of populations, polls and surveys, image processing. And I examine how well students' pure mathematics knowledge might prepare them for modelling in the information age.

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Measuring Pedagogies from Secondary School to University and Implications for Mathematics Education (in UK and abroad)
The aim of this paper is: (a) to show how we developed measures of teaching practices in mathematics from teachers' and students' perspectives; (b) to report some models using these measures and implications for mathematics education. In between the two main aims we will also show how 'measurement' results can further inform mathematics education debates.
The presentation will build on results from our previous ESRC funded projects on transition to mathematically demanding subjects (www.transmaths.org) in UK Higher Education, an extension of this work in Norway, and the initial findings from an ongoing ESRC funded study of teaching and learning secondary mathematics in UK (www.teleprism.com). In particular we will focus on the following:
- The development of the measure of teacher self-reported pre-university pedagogy and its association with students' learning outcomes [1];
- The 'conversion' of this pedagogy instrument [1] into two measures of students' perceived pedagogical experience before and during their first year at university in UK and in Norway (with some reference to cross-national comparisons and their implications for mathematics education);
- The extension/development of these instruments backwards to capture secondary students' progression into secondary schools (Year 7 to 11).
Beyond validation, which is performed within the Rasch measurement framework, we will also seek to explore and report on results about the associations of these measures with other learning outcomes. Some illustrative findings point to an association of declining students' mathematical dispositions with transmissionist pre-university (and at university) teaching. These relationships will be further explored with new data from earlier educational phases and other contexts.
[1] Pampaka, M., et al (2011). The association between mathematics pedagogy and learners' dispositions for university study. BERJ-DOI: 10.1080/01411926.2011.555518(iFirst).

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Understanding and dialogue in mathematics classrooms: Two perspectives from Vygotsky/Leontiev and Bakhtin/Volosinov
According to Volosinov/Bakhtin, dialogue is always open and understanding consists of an utterance-response pair within such a dialogue. Seen this way, teacher-learner interactions in dialogue in

classrooms are never quite closed or complete, and neither is 'understanding' in such dialogic interaction. But according to Vygotsky/Leontiev, teachers and learners can undertake joint activity of studying together; the object of activity might be new understandings of the mathematics/task/problem, and understandings of these understandings. We argue that the apparent disjuncture in the two perspectives here might be overcome: mutual understanding is never complete, and learning-and-teaching is exactly a joint process attempting this impossibility, i.e. attempting to understand one another. We will share some examples where such a perspective seems to provide insight.

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The rise and fall of an investigative approach to mathematics in primary education- a discussion opportunity
This session is an opportunity to share points of view about the role of investigative mathematics in primary mathematics teaching. From 1982 when the Cockcroft report promoted this teaching style, through the introduction of the National Curriculum and the National Numeracy Strategy to the latest Ofsted research (2011) on 'good practice in primary mathematics', what can we say about the current state and place of investigation in primary schools? In the light of the status of national and international league tables should we continue to promote open-ended mathematics? How does investigative work sit with assessment practice? Do student teachers see value in teaching process skills? Just some of the questions which we might explore.

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'Going it alone' within further mathematics
In this paper I examine the idea of choosing further mathematics as positioning oneself/being positioned as belonging to an imagined collective (Anderson 1991). My previous research has analysed students' accounts as practices of neoliberal self-entrepreneurism that construct them as indidivually successful (or not). Here I consider the roles of belonging and not belonging as practices of the self that are produced/reproduced by the collectives to which students belong . I use the examples of three students to show how they negotiate different senses of belonging within their accounts and manage to produce simultaneous discourses of inclusion and going it alone.

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Exploring changes over time in the types of mediational modes and the nature of inter-mode transitions in GCSE mathematics exams
Mathematical activity is characterised by the use of a range of mediational modes – different semiotic systems such as numbers, words, algebra, Cartesian diagrams etc. – and transitions between and within mediational modes. The project *Evolution of the Discourse of School Mathematics through the Lens of GCSE examinations* is studying the ways in which the mathematical activity expected of students has changed over the last few decades. We are doing this by analysing the discourse of examination papers, using linguistic tools. Our analytic framework includes identification of transitions across and within mediational modes. In this session we will consider differences in the number and types of mediational modes involved in tasks (questions posed and answers expected) and the number of transitions within the same mode and between different modes, distinguishing between those provided by the examiner and those expected to be completed by the student. Using examples of questions from different years, we will illustrate the implications of differences in the numbers and types of modes and transitions. Mediational diversity and transitions provide tools for describing complexity of tasks and the related structuring of questions. They also have implications for how the student is engaged in decision-making and how the student understands mathematical ideas and relationships between them.

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Continuous and discrete knowledge: Analysing trainee secondary teachers' mathematical content knowledge change through 'knowledge maps'

Shulman is renowned for shifting the focus of teacher knowledge research onto content knowledge for teaching with the introduction of his categories of content knowledge. Following Shulman, many researchers have defined further categories of knowledge for teaching or refined his ideas (e.g. Deborah Ball and colleagues). Many accept that there is a specialised knowledge of mathematics for teaching. However, others argue that teaching is simply utilising mathematical content and processes within a different (teaching) context, rendering categories of knowledge types unnecessary (e.g. Anne Watson). Both points of view are taken into account in the introduction of 'continuous' and 'discrete' knowledge – a proposed metaphor for how mathematical content knowledge is held within teachers' minds. Not only do these terms aim to reconcile these seemingly opposing perspectives, but they take into account the dynamic nature of knowledge, allowing it to be represented in the form of 'knowledge maps' for comparison over time. This session aims to discuss participants' views of the affordances and constraints of the proposed metaphor and representation for research into teachers' mathematical content knowledge.

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Class room or class struggle? Next steps in unification of Bourdieu's sociology with cultural psychology
I have recently (see Mind, Culture, and Activity, 2011, and ESM online, 2011) tried to find a synthesis of Bourdieu's analysis of schooling as 'reproduction' of class society with Vygotskian perspectives on schooling as a leading activity/zone of proximal development: this is accomplished in the notion that schooling is production of labour power, but that labour power is contradictory, having both use and exchange value. The consequences for mathematics education are that it contains contradictory practices or activities: those that reflect the cultural arbitrary in schooling and those that reflect the use-value of mathematical labour. I argue that there are implications for mathematics classrooms, the curriculum, pedagogy, etc. Arguably, classrooms are arenas for class struggle.

Working groups

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Sustainability and Mathematics Education
Although close to the end of the UN Decade of Education for Sustainable Development (2005-2014), there seems to be wide variation in the extent and nature of action on sustainability issues in Higher Education Institutions. In schools, too, some communities have made major shifts in practice whilst others have different priorities. The coalition government has introduced changes of policy, including a move away from the 'Doorways' intiative, and it is not yet clear what the impact of these policy changes might be.
However, these are primarily generic educational initiatives. To what extent is sustainability an issue to be addressed by mathematics educators? Sustainability does not yet seem to have become a central issue for mathematics education.
In this working group, we will explore:

- Different interpretations of what "sustainable mathematics education" might mean.
- Ways of promoting awareness of and action around sustainability issues through mathematics education.
- We will also share resources, and network to build capacity.

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Mathematics Education and the Analysis of Language
In this session we will present two methods for the analysis of classroom dialogue, one based on conversation analysis and one based on multi-modal techniques. We have a transcript for participants to try out these two analysis methods. We will then invite participants to consider what has emerged from the combination of both approaches.
This is the third meeting of the working group, but attendance at previous meetings is not necessary - everyone is welcome!

Rogers, Leo
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History in the Mathematics Curriculum
The Working Group aims to select, share, trial, evaluate and modify appropriate material in the light of teachers' experience so that together we may discover sensible ways of introducing the "rich historical and cultural roots of mathematics" to our pupils.
Review of the context (rumours or facts?) about the new curriculum and information about the European Community COST Project Proposal. Sharing news and looking ahead.

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From research to practice: making an impact?
This working group continues to explore ways in which our research might make an impact by informing practice at classroom, institutional and/or systemic level. Following earlier discussions at BSRLM day conferences this meeting will explore a particular and current issue.
The Royal Society's recent call for views to inform its project, "Vision for science and mathematics education 5–19" asks respondents to address five key areas:

- Teachers (and the wider workforce)
- Leadership and ethos
- Skills, curriculum and assessment
- Infrastructure
- Accountability.

The call for views states, "We would particularly welcome any robust data or other evidence to support your views about improving the science and mathematics aspects of the education system and would be grateful if you would reference this fully so that it can be followed up."
What is the research that BSRLM members can point to that might make a significant contribution towards such a vision? How might this best be presented to influence and make an impact?