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Janet Duffin Lecture

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'What works... and who listens? Encouraging experimental methods in education research

The gold standard research design for building evidence in medicine is the true experiment or randomised controlled trial (RCT). Recently, after a 50 year lull in activity, there has been a resurgence in the use of experiments to inform education policy in the United Kingdom (UK) and there is a growing realisation by policy-makers that other research designs cannot effectively answer the 'What works?' question. A House of Commons select committee report was highly critical of the UK's Department for Children, Schools and Families (DCSF) for not supporting RCTs more widely.

Under the last government we undertook the first DCSF-supported RCT. This was an experiment evaluating an intensive one-to-one mathematics intervention: Numbers Count, which formed part of the previous government's flagship numeracy policy intervention, Every Child Counts. We rigorously designed, conducted and reported this trial to CONSORT guidelines and published it in the RME Special Issue on Experimental Methods in Mathematics Education Research.

In this lecture Carole will discuss the design and results of the trial, and the implications for education policy, within the context of experimental evidence-based education.

Carole will also discuss the importance of using the CONSORT guidelines in the design and conduct of experiments in order to increase their reliability, and will conclude with an assessment of the current status of the field of experimental methods in education.

Research presentations

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An investigation of developing teachers' understanding of using a dialogic approach in Saudi primary mathematics classrooms

Classroom talk and dialogue has become fundamental to students' learning mathematics and much research has been focused on the ways teachers interact with their students and the quality of dialogue between them. Drawing on recent developments in dialogic approaches to learning and teaching of mathematics, this study investigates how Saudi mathematics teachers develop their understanding of classroom dialogue through a professional development process in mathematics teaching. The study involves multiple case studies collecting qualitative data on i) teachers' espoused beliefs about their teaching practice and dialogic teaching and ii) teachers' enacted practices using dialogic teaching principles. The participants were three male primary mathematics teachers in third, fifth and sixth-grade classrooms. The paper includes early analysis and discussion about Ahmad as one case study.

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An intervention programme using fingers and games in primary classrooms to improve mathematical achievement

In recent years studies have demonstrated the positive association between mathematics achievement and finger-based numerical representations of number where training in finger gnosis has led to gains in mathematical skills. An association between mathematics achievement and numerical magnitude processing has also been established. Playing mathematical games has proved beneficial. The aim of the current study was to evaluate the effectiveness of an intervention which combines finger gnosis training with games to see if this combined intervention is more effective than either alone. The hypothesis was that the visual representation of fingers and dot patterns would act as mediators between the child's non-symbolic representation of number and symbolic representation used in calculating. 133 children aged 6 to 7 years from five classes took part in the pre-test, intervention, post-test study. The classes were randomly assigned to different conditions: finger gnosis only, games only, full intervention and no intervention control. Results demonstrated that the pupils in the two full intervention groups made statistically significant greater improvement in mathematics achievement tests than those in the other groups, suggesting that the combined intervention could help children of this age to make connections between symbolic and non-symbolic representations of number and raise mathematical achievement.

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What are teachers' priorities in their decisions when management interferes with mathematical learning?

What are teachers' priorities when they make decisions in situations where classroom management interferes with mathematical learning? In this session I present research conducted with colleagues in the UK that explores teachers' pedagogical and epistemological considerations through teacher written responses to situation-specific tasks. Then I introduce a type of task that addresses both mathematical learning and classroom management issues; and, I discuss the written responses of 21 prospective mathematics teachers to a task in which a student's unease with algebra is met with another student's dismissive and offensive response. The analysis I present here observes a lack of balance in the participants' responses (in favour of behavioural issues and at the expense of epistemological issues) and ponders implications of this for actual teaching practice. The session will include a brief period of engagement with the aforementioned task.

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The effects of setting and mixed ability grouping on pupils' mathematical self-perception in year four

There is considerable literature debating the positive and negative effects of setting on the basis of prior attainment (commonly referred to as 'ability') on the mathematical self-concept of pupils. From a practitioner's perspective the research findings are thought provoking as Muijs and Reynolds (2005) suggest setting has the potential to harm pupils' self-concept when they are placed in lower 'ability' groups. Boaler (2013) found that setting harms the academic achievement of pupils in the low and average 'ability' groups

and does not improve the achievement of the pupil's in higher 'ability' groups. Consideration of the alternative to setting led to this comparative case study in which I investigated the effects of setting on the basis of prior attainment and mixed ability grouping on the mathematical self-perception of two year 4 classes. The overall findings suggest that mixed ability grouping has no statistically significant effects on mathematical self-perception. However the qualitative data contrasts pupils' perspectives of setting based on prior attainment and mixed ability grouping and suggests a difference in pupils' perceptions of their learning environment, the influence of different peer groups and, in some cases, their mathematical self-concept. Furthermore social comparison was more prevalent in setting.

Barber, Patti; Barmby, Patrick; Fielding, Helen; Huntley, Ray; Ineson, Gwen; Rowland, Tim & Voutsina, Charis

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Using Grounded Theory: A collaborative approach

There are many video clips that are widely available to support CPD for teachers but what do student teachers make of this material? This study focuses on student teachers following a one year post graduate initial teacher education programme. Student teachers were given a video clip to watch about supporting pupils make the transition from using the grid method to the standard written method. They split into small groups to discuss their initial thoughts and then came back together as a group (approximately 30 students) to share their thoughts more widely. Following this discussion they were asked to write a short reflection about the session.

Seven researchers used grounded theory to analyse the data and this session will provide an overview of the approach we took. We will begin by showing the video clip used in the study and some excerpts from the student teachers' reflections. We will explain the collaborative approach taken to coding the data and ask participants to engage in discussion about the codes we have assigned. Following this, early findings from the study will be discussed.

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Discrete or continuous change: can a dynamic representation facilitate development of reasoning in mathematics?

The concept of inclusivity within 2D shapes can be difficult for school students to grasp. I describe a task using a dynamic perpendicular quadrilateral which students dragged to generate different triangles and quadrilaterals/ I hoped this would encourage them to develop the idea of inclusive relations between the rhombus and kites. Pairs of 13 year old students worked with the dynamic figure whilst their dialogue and on-screen activity were recorded. I describe the strategy of dragging to maintain the symmetry (DMS) of the figure which I claim has the potential to mediate the concept of a 'dragging family' of shapes (leading to the concept of inclusivity). As such DMS is a 'dragging utilisation scheme' in the Vygotskyan sense. However, in order to move towards this understanding it is necessary that students perceive dragging activity on the figure as an action resulting in a continuously changing figure which morphs through an infinite number of shapes. I describe how I used an animation of the figure under DMS as the catalyst to move the students' thinking towards the 'dragging family'. My findings suggest that enabling students to view change through continuous rather than discrete representations can help to develop mathematical concepts.

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Towards improved congruency between shared policy goals and mathematics classroom practice

Mathematics education policy initiatives rely on interpretation and translation by a succession of layers of 'policy actors' (Braun et al., 2011), through whom they are 'iteratively refracted' (Supovitz and Weinbaum, 2008) – and there is often substantial room for 'creative compliance' (Ball, 1993) that can subvert the apparent intentions of policymakers. However, some policies faithfully reflect commonly valued goals, including those of many classroom teachers. I suggest these include Mathematics GCSE 2010, which in principle enjoyed widespread support of the mathematics education community (Noyes et al., 2011), though the developments it envisaged – deep conceptual understanding, rigorous reasoning and genuine problem-solving - are known to make considerable demands on teachers (Euridyce, 2011). I discuss a longitudinal (2.5 years) study which followed two well-placed departments enacting the GCSE with very different outcomes, and identify from it a number of characteristics of implementation, at a variety of levels, which apparently served to either support or undermine principled enactment of the policy. I use a variety of lenses to understand the impacts and suggest how these might be addressed.

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Exploring the role of context in statistical tasks

While abstract calculations may be necessary in solving statistical tasks (e.g. practice problem, example, laboratory sheet, test question), statistical thinking involves the ability to understand and utilise the context (e.g. scenario, dataset) of a task to justify statistical inferences and draw conclusions. Some research argues that context helps with the students' development of relevant statistical thinking skills. Yet, others have claimed that context can hinder students' sense making of statistical concepts. In particular, the aim of this study is to explore how statistical tasks are set in context in undergraduate statistical modules.

In this session, multiple sources of data from three undergraduate statistics modules will be used to develop a conceptual framework characterising how and why lecturers use context in teaching and assessing statistics. Qualitative data consists of lecture slides, hand-outs and participant observation of lectures. The focus is on concepts that students encounter in statistics modules aimed at non-specialist students. The data reveals some key issues relating to the role of tasks set in different contexts in teaching statistics at university and the nature of the statistical activity expected of students.

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Teaching mathematics at university: practices, values and participation

We report on a developmental design research study in an engineering mathematics undergraduate course, where previous attempts to increase participation by introducing mathematical modelling has failed. We take ideas from socio-political theories to frame the teaching (re-)design and use a socio-cultural theoretical framework – where learning is seen as participation - to evaluate its impact. We collected data from students' written feedback and used peer observation to reflect on and refine the teaching strategy and to analyse the students' learning. Results showed a positive participation (although not all

students engaged or liked the approach) and the final assessment results were very encouraging. We will discuss the implications of these results for mathematics education at university.

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The views of pre-service teachers on the school-based learning component of their mathematics teacher preparation programme

Teacher preparation is a highly contested area in England with a range of epistemological approaches being promoted through the availability of different preparation routes. The dominant model of teacher preparation used by programmes led by university education departments is that of developing reflective practitioners. However, other models, including those coined as ‘craftworker’ and ‘executive technician’ in Winch et al. (2013), are increasingly in evidence with the recent increase in new school-led teacher preparation programmes. Aspects of professional training such as learning from a more experienced mentor, learning as part of a ‘community of practice’ (Lave & Wenger 1991) and the need for practical experiences are all characteristics that elements of teacher preparation share with models of vocational learning and those of other professions. This paper seeks to explore some of the views of those on secondary mathematics teacher preparation programmes with regard to the characteristics of their school-based learning and their experiences on school placement. Data collected from those on a well-established university-led Postgraduate Certificate of Education (PGCE) programme are compared with data from those on a new school-led School Direct programme in order to explore the different conceptions the two groups have towards their school-based learning.

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The discursive construction of learning school mathematics

Beliefs, identities and social and cultural norms have all featured heavily in mathematics education research over the past few decades. Most studies have focused on results from large scale surveys or smaller scale in-depth interviews with teachers and students. However, it is also possible to explore learning mathematics on the micro scale through the analysis of interactions in the moment in classrooms. In this session, extracts from whole class interactions in mathematics classrooms with students aged between 12 and 14 years are used to illustrate what it means to do mathematics, what it means to teach mathematics, and what it means to learn mathematics. Drawing on ideas from ethnomethodology, discursive psychology and positioning theory I will explore how mathematical identities related to teaching and learning are discursively constructed, but also how these evolve dynamically through the classroom interactions and the implications these have on the nature of mathematics that students experience.

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REALMS Project Dissemination: Findings, current practices, and future research and development agenda

This session will focus on reviewing findings from the Raising Expectations and Achievement Levels for All Mathematics Students (REALMS) research; exploring the video case studies produced for research dissemination and CPD; discussing current CPD arising from the REALMS project (participant led); and exploring possibilities for an

ongoing research and development agenda building on the findings. The research aimed to explore the potential of a pedagogical approach called ‘Complex Instruction’ (CI) that was designed in the US to make groupwork more equal, addressing the status differences that often emerge when students work in groups. The research set out to systematically assess the efficacy of using CI in English secondary mathematics classrooms. In addition to quantitative data about achievement on national tests, qualitative data provided rich case studies of: 1) mathematics departments struggling to take on board new challenges in the context of competing external pressures; and 2) small group collaborative mathematics learning. Discussion of the research findings will seek to focus on critical development of insights and implications for practice.

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Supporting mathematical thinking during online communication: A preliminary study

Collaborative peer talk plays an important role in the development of sound mathematical reasoning (Davison 1985; Schoenfeld 1989; Davison & Kroll 1991). Many researchers have shown online collaborative learning to be at least as effective as offline settings, if not better (Hiltz et al. 2000; Vonderwell 2003; Garrison 2005). However, “the development of e-learning in the sciences in general, and mathematics in particular, has not met the general expectation” (Ahmed 2008), which may be (in part) because “practical and intuitive mathematics input for users is still under investigation” (Mikusa et al. 2005). There have been some studies incorporating elements of online collaborative learning in mathematics education (Sande 2001; Noss et al. 2002; Simpson et al. 2006; Noss & Hoyles 2006). However, research on what constitutes ‘practical and intuitive’ is very limited, and research with a specific focus for mathematics education is sparser still. This session will outline the results of a focus group study exploring user experience and how the flow of mathematical thinking can be supported during online communication

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How do English children fare in international comparisons of mathematical performance?

If the rhetoric of politicians is to be believed the mathematical achievement of English school children is dire and declining or at best stagnating. Close scrutiny of the data reveals a complex picture that is not consistent with this simplistic political message. Drawing on England’s outcomes in PISA, TIMSS and PIACC over the years I attempt to illuminate some of this complexity. International comparisons also reveal potentially interesting differences in practices between primary and secondary phases.

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“It’s helping your child experience the world”: How parents can use everyday activities to engage their children in mathematical learning

We present the content and preliminary findings of the "Everyday Maths workshops" for parents. The workshops were designed to (i) help parents reflect upon and “find” the mathematics in their everyday lives, and (ii) support parents in developing conversations with their children around everyday mathematics, with the view of empowering parents to help their children’s mathematics learning.

Workshops were run once a month in four primary schools in Southwest England (October 2013-February 2014). Parents of children aged 7-9 were invited to participate.

Schools were sampled based on their differences from each other (e.g. schools varied in socioeconomic background, ethnicity, and performance at Key Stage 2).

Preliminary findings suggest that through the workshops some parents were afforded opportunities to develop a “mathematical lens” which led them to identify the mathematical reasoning underpinning decisions and actions in everyday life. This inspired creativity insofar as parents began to initiate conversations with their children about mathematics and (for the first time) construct activities which engaged children in mathematical thinking. However, whilst some found the workshops empowering, others either struggled to grasp the concept of everyday mathematics and/or struggled to converse with their children about mathematics. Implications of these outcomes will be discussed

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Mathematical content knowledge of pre-service teachers: An Irish perspective

Shulman (1987) identifies deep subject matter knowledge that is multifaceted and flexible as a central feature of the knowledge base required for teaching. More recent research continues to highlight the specialised mathematics content knowledge required for teaching (Ball, Thames and Phelps, 2008). In the Irish context, Corcoran (2005) researched the mathematical content knowledge of undergraduate students on an initial teacher education degree course. Among her findings, Corcoran observed that the mathematics which many of the students brought to the course was overly procedural. Since 2005 the secondary school mathematics curriculum has been changed to reflect a growing emphasis internationally on a problem-based approach to mathematics learning which emphasises learning through understanding rather than by rote. In November 2013 we administered a revised Subject Knowledge in Mathematics Audit (SKIMA) (Rowland, Martyn, Barber and Heal, 2001) to 460 undergraduate students on an initial teacher education degree course. We collated the results and in this presentation we will discuss the responses of students to SKIMA tasks, focusing on those students who could not remember standard algorithms and needed to find alternative methods.

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Investigating teachers' beliefs about ways to promote students' cognitive engagement in mathematics

Promoting student engagement is important for all students' learning of mathematics. Although engagement is a multidimensional construct, this research focuses on the role of cognitive engagement, which includes self-regulatory and metacognitive processes that are influential for promoting students' learning outcomes. Previous research revealed that teacher beliefs about cognitive engagement were less refined than their beliefs about other kinds of engagement (Skilling, 2013). We used surveys to investigate secondary teachers' beliefs about and practices used to promote cognitive engagement in their classes. The survey asked participants to respond to questions about two fictitious teacher scenarios in which Teacher A and Teacher B are preparing their students for a test, with each teacher emphasising particular types of engagement strategies. Surveys from 35 teachers across 10 secondary schools revealed that about half of the participants identified with Teacher A, considering the following strategies to be particularly important: completing practice questions, supporting students' outside of class time, and providing students with a list of topics to revise. The participants who identified with Teacher B considered it was

particularly important to encourage students to self-assess their competency, to help develop individual plans based on their needs, and to monitor student revision progress.

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Ethical issues in guaranteeing anonymity

In writing a case study of a particular student it has become apparent that her personal circumstances are sufficiently unique she will be identifiable despite having guaranteed anonymity. This session will take the form of a discussion exploring the ethical issues likely to be encountered in using this data and what approaches might be taken to retain integrity.

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Progression towards functions: an initial comparison of data from England and Israel

We present some comparative data and comments about students' progression towards understanding the function concept in England and Israel. A survey of conceptual understanding that contributes to knowledge of functions was carried out with 120 English students and 110 Israeli students. We are in the early stages of comparing the outcomes. The curriculum treatment of functions in Israel is formal from year 7, and in England is formal from about year 10 or 11. Curriculum has a part to play in the differences we have identified, but there are also indications of ways in which teaching makes a difference. Our comparison raises several questions, for example about the roles played by sequence generalisation and functions machines in early secondary mathematics. We will share some of our questions and conjectures.