Abstracts of Review Talks

The Languages of Mathematics

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Students of mathematics have to juggle with at least three mathematical languages: rhetoric, symbolic and graphical. Each of these languages have distinct characteristics and can be used in different ways to support, or to alienate, sense-making. How can insights into the nature and characteristics of these languages enlighten mathematics education in all its branches – curriculum development, the practice of teaching, research on learning, teacher education? This talk will provide thoughts, proposals and open questions on these matters.

What Do 'Good' Teachers Know? Investigating Teacher Professional Knowledge

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'Everyone remembers a good teacher' was the theme of a recent teacher recruitment campaign in the United Kingdom, but what is it that is considered 'good teaching' in science and technology? Drawing on empirical work carried out with teachers in Australia, Bangladesh, Canada, Finland, India, Iraq, New Zealand and the United Kingdom this paper sets out aspects of teacher professional knowledge by presenting a common frame of analysis.

What constitutes the school science and school technology curriculum has gone through considerable change in many countries over the last twenty years and the analytical framework can be shared with teachers to enable them to use it as a tool to focus on their own professional development needs and personal beliefs about successful teaching. Considering their subject knowledge, pedagogical knowledge, 'school knowledge' and their own rationale for the teaching of science or technology, teachers are able to articulate their professional priorities. Satisfying those professional needs, however, in an environment where teachers are 'time-poor' and under considerable pressure to be in school working day by day with their students to achieve examination results is an acute challenge for teacher educators and policy makers. The paper will consider open and distance learning as a model for effective school-based teacher professional development. By making the school itself the site of learning and the classroom, laboratory or workroom the arena of change, teacher professional growth can be not only effective but cost-effective.

Social Dimensions of Mathematics Education

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Mathematics has been an integral part of the Indian school curriculum ever since the inception of modern schooling in the country. Policy documents have emphasised the importance of mathematics and its subject matter has been of much concern whenever changes in curricula or textbooks have taken place. Changes in school curricula have often

been driven by the developments in Mathematics and the subsequent need to update mathematical knowledge. In recent years, the radical shift in understanding learning within models of child development and the attendant effort to reduce information load on children has therefore met with much resistance.

For parents and students mathematics as a school subject gains importance for its association with high-status professions – traditionally medicine and engineering and now increasingly the business professions – and the subsequent opportunities that it makes available. Mathematical knowledge therefore acquires importance not for its own sake but for what it can deliver. Success in school mathematics has little to do with the classroom or with the child's interests or motivation. Its importance within the academic context is totally out of proportion to either its applicability in the real world, its ability to provide a knowledge base for scientific and technological understanding at more advanced levels of learning, or to the broad cognitive skills it is often claimed to foster.

This paper is an attempt to explore the factors that work subtly in classrooms, within schools and outside them to limit access to what the mathematics syllabi demand in terms of skill and competence. In reviewing research into the teaching and learning of school mathematics, curricular concerns and policy decisions, it will also examine the social and political contexts within which students achieve "success" and children and teachers get constructed as mathematically "competent" or "incompetent" and the ways in which this compels the focus of any analysis or intervention to be confined to the practice of learning and teaching within the classroom.

Universalization of Elementary Math and Science As a Scientific Problem

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With universal access to education becoming a legal right of every child citizen of India, a number of questions arise. Firstly, what is the current status of the problem in the nation? How can this be reliably and accurately assessed? What standards must be set for compliance? Secondly, how can we systematically work towards achieving these standards in the shortest feasible time period?

It is proposed that the problem of universalization of education can, and must be perceived as a scientific problem, and engaged with at least the same seriousness with which some other mass scientific programmes were taken up in history. Science must begin by seeing the elephant, when it is visible. When universalization of primary mathematics is taken up as a scientific problem, it is clear that math pedagogy is only one of its important aspects. Other aspects like systems, administrative involvement, logistics, teacher involvement, assessment and training are no less important for delivering, or not delivering, outcomes. Some of the most basic issues of universalization are political and organizational, requiring political and organizational decisions. These cannot be avoided but must be addressed scientifically. We discuss some specific experiences and problems with implementing mass programmes.

The question of universalizing science has all the above mentioned dimensions of math education as well as some more. The concept of the real world as a school science laboratory is crucial to universalizing science. Can every school become a discovery school? We discuss how a terrasun laboratory can be set up in each school at a cost that no school cannot afford. A comprehensive package of low cost and no cost experiments exists which can make world class science education accessible to every child. Mass science campaigns like Year of Planet Earth, and International Year of Astronomy 2009, can play a catalytic role in upgrading science education on the mass scale necessary to achieve universalization.

Discourse and Learning in the Science Classroom

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Studies of discourse in science classrooms are relatively recent. If we consider the seminal work of Lemke (1990) as a starting point, from that time a variety of studies emerged in which discourse in science classrooms is considered from different perspectives. There are studies that consider the teacher-students interactions and how the patterns of discourse that emerged from these interactions framed the opportunities for learning science. Although many of these studies found that questions were used to control the classroom conversation, usually through the use of discursive patterns like IRA (Initiation-Response-Evaluation) (for example Carlsen, 1991, Lemke 1990), there are some studies showing that questioning can have a different purpose, allowing and encouraging student participation in the lessons (for example, van Zee & Minstrell, 1997). Others, yet, sug-

gested that a balance between controlling, serving authoritative purposes, and encouragement of participation, serving dialogical purpose, is a way of conducting a lesson, as science is predominantly an authoritative discourse that has to be learned through dialogue (Scott, Mortimer & Aguiar, 2006).

In this article I am going to present a review of selective studies of discourse and learning in science classroom considering, beside those that analyze teacher-students interactions, the studies that focus on students' interactions and how the participant structure promotes student engagement in the classroom discourse practices (for example, Cornelius & Herrenkohl, 2004, Engle & Conant, 2002). And thirdly, we shall review some studies that analyze argumentation and the ways evidence is used in science classrooms (for example, Driver, Newton & Osborne, 2000). Although these studies tend to consider the logic and not the rhetoric of argumentation, for example through the use of Toulmin's (1958) model, we shall analyze them because argumentation is central to reveal the nature of claims and warrants for scientific knowledge.

I shall finish this review giving an example of my own analysis of classroom discourse in which, following Kelly's (2007) suggestion, I consider ways that discourse study can be used to inform teacher education. Accordingly, I will analyze a particular science teacher and the ways he alternates between authoritative and dialogic discourse to guide the students meaning making process in his classroom.

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Design and Technology: An Emergent School Subject

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How can one reconcile Gandhiji's self-reliance principles envisioned in his Buniyadi Taleem (Basic Education) and Nayee Taleem (New Education) and iconised by the disciplined operation of a charkha, with Tagore's dream of unleashing the nation's individual and social creativity embodied in his conceptualisation of the Shantiniketan? The answer seems to suggest itself: a suitable education in design and technology. Technology and Design are organically linked. The latter stands for innovation and creativity, while the former is the very foundation of self-reliance.

The most compelling arguments for including Design and Technology (D&T) as part of school education arise from what it means to be human. I will argue for the inclusion of D&T as part of Indian school education in terms of its cultural and cognitive relevance. I will show that design and its practices are not subsumed either within the arts or the science school subjects. On the other hand, the cognitive benefits of designing are on par with and complimentary to the knowledge and skills gained from engaging in the sciences, and the humanities, including the arts and literature. Studies have been carried out at HBCSE on design and cognition as well as on the collaborative and communicative modes of working on D&T units. I will draw upon these studies carried out in different Indian school settings, and related studies from elsewhere, to illustrate how learning to design and make at the school level can empower students.

I will touch upon the need for a distinct model of D&T education for Indian schools to enable equitable participation of students from diverse backgrounds, and propose the salient features of a possible D&T curriculum. I will briefly discuss the challenges of D&T education curriculum for Indian schools. Arguing that D&T is a vehicle for multiple modes of expression, creativity and design, I will discuss how Indian multicultural classrooms can benefit from communication and collaboration centred D&T activities.

People's Knowledge of Proportions in Everyday Life and in the Classroom

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There are so many occasions for people to learn about proportions outside school that it has to be puzzling that many students find it difficult to solve mathematics and science problems involving proportional reasoning in school. People with little school instruction typically solve proportions problems in everyday life by methods that focus on quantities. These methods originate in the schema of one-to-many correspondence, which keeps the ratio between the quantities fixed, but as a theorem in action, not understood explicitly. This presentation will review studies that describe this informal knowledge and discuss how it could be transformed into formal mathematical knowledge, thus offering a better foundation for teaching students about proportionality in the mathematics and science classroom.

Gender Exclusion in Science: Questions about Epistemology, Policies and Institutional Frameworks

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Critical epistemology has indicated that the process of generating scientific knowledge and the prevailing ethos within its institutions is not uninfluenced by the predominant norms and values in society. Influenced by the existing social, political and economic context, scientific institutions and ethos perpetuate certain exclusionary practices that prevent large sections of population including women from participating in the exciting process of knowledge creation. Such exclusionary practices raise questions about social equity and inclusion. There is also the possibility that the exclusionary practices restrict the growth of scientific enquiry and knowledge by not drawing upon other knowledge systems and divergent ways of knowing.

This paper draws upon Women's Studies scholarship to indicate the gender blindness in India's science policies and the embedded institutional practices that excludes women from science. The data is drawn from a study commissioned by the Indian National Science Academy, New Delhi, to understand the socio-economic barriers to Indian women's entry into science. It begins with a brief review of Women's Studies engagement with science to address the following questions: 1) The politics of knowledge generation that excludes women from scientific institutions and creative process; and 2) Would women's entry into science alter the process of knowledge generation?

From this location, this paper examines the Indian science and technology policies. It also highlights some of the institutional mechanisms that are either gender blind or actively create structures of exclusion. Subsequently locating the organizations in the context of the current processes of change, it examines if the process of exclusion would be exacerbated in the wake of the current socio-political and economic changes. Finally it tentatively examines the possibilities of women bringing about a different perspective to science.

Objectifying Symbols: The Uneasy Journey of the Mathematical Object from the World, to Mind, to Discourse

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Those who try to crack the puzzle of mathematical thinking cannot avoid asking the preliminary question of the nature of mathematical objects and of their relation to symbols. While seeking an answer, the investigators of mathematical thinking may wish to look at the history of modern semiotics, from its beginning in epistemologically-oriented work of Peirce, Saussure, Lacan and Jacobson to the research that is being done these days by those who call themselves social semioticians. The main questions asked by successive generations of semioticians is that of the nature and origins of the 'referents' of symbols. In the case of mathematics, these referents are called mathematical objects. The transformations of semiotic thought first relocated mathematical objects from the 'real world' to human mind, and then from the human mind to human communication. In this talk, after a brief summary of these developments, I will propose the view of mathematical objects as discursive constructs and will present some of the consequences of this stance for the research in mathematics education and for the practice of teaching and learning.

First Steps Toward Proof

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Proof is and has been for long a problematic area in the teaching of mathematics at the school level. While proof remains central to the discipline of mathematics (articles like Horgan, 1993, notwithstanding), its pedagogic role at the school level remains unclear. On perusing through the questions asked in the Math Forum site (http://mathforum.org/) one sees the demoralizing nature of the difficulties felt by students

The noted mathematics educator P K Srinivasan had listed the first exposure to "Proof" as one of three critical points at which children tend to switch off from the subject altogether.

A major contributory factor to this problem is surely that we introduce proofs at too late a stage. Moreover, it is done in too abrupt, too formal, and too stylized a manner. This results in a feeling of alienation for the child, who finds proofs unmotivated and unnatural. This feeling is added to if what is being proved looks "obvious"; and a majority of the early results encountered in geometry do indeed look "obvious". (Recall some of the results we meet early in the study of geometry; e.g., the "bridge of asses" theorem.)

Whatever be the cause, the problem challenges us to respond with some effective pedagogy. The cost of not doing so is considerable. A child reaching the senior grades without a significant exposure to the culture of proof has lost a valuable opportunity to experience a central component of the discipline of mathematics.

In this paper we report on a study done with children in grades 8 and 11, seeking their approaches and responses to the notion of proof in mathematics. We also explore some ways in which proof might be introduced to young children in a way that intrigues them and holds their attention, through non-geometric contexts like number theory and graph theory.

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Learning and Teaching Design and Technology: Meeting Needs, Developing Capability

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Recent years have seen Technology Education grow and spread across regions, countries and provinces as a subject taught and learnt in mainstream schooling. Within this global growth, a distinct development has been of "Design and Technology" as a unified learning area. This paper will provide a rationale for the linking of Design with Technology within the curriculum, identifying the potential this affords, providing a conceptual framework for learning and teaching and exploring the issues and opportunities this raises for developing effective pedagogical approaches.

Through the paper I will explore reasons why learning Design and Technology is important for individuals and for societies, consider the debates about what needs to be learnt and outline how this learning might take place. Within this I will focus on the value of a capability approach and the importance of learning through doing by engaging in an iterative, responsive process. I will discuss the implications of this for pedagogical approaches to developing knowledge, skills and understanding, including issues of cognition, learning style and designing style. I will draw particularly on research that has developed our understanding both of the nature of Design and Technological capability and of ways of nurturing this capability through the learning experiences we can provide for all children in general education, at both primary and secondary levels.

Finally, I will explore the pedagogical issues this raises for teacher education, drawing particularly on experience gained through preparing new Design and Technology teachers in my own institution – Goldsmiths, University of London.