

DEVELOPING MATHEMATICS TEACHING AND TEACHERS

A Research Monograph

*Olwen McNamara, Barbara Jaworski, Tim Rowland,
Jeremy Hodgen and Stephanie Prestage*

CHAPTER 1:

Prologue

1

PROLOGUE

Introduction

This monograph is a ‘professional’ review resulting from a ‘practitioner’ inquiry conducted by a number of mathematics teacher educators and researchers into the initial and continuing education of mathematics teachers in primary and secondary schools, and the associated development of mathematics teaching. The Council of the British Educational Research Association (BERA) defines a professional review (or ‘user’ review) as one that “can be seen as normally arising from an academic review in such a way that it: is devised and written by researchers and users working together; brings together the findings of trustworthy research studies on significant educational questions of immediate concern to practitioners and/or policy makers; channels them into a user-friendly and trustworthy document, which aims to inform critically the thinking of practitioner and/or policy makers, and thereby stimulates discussion and worthwhile educational action” (Bassey, 2001).

We believe that such a review of research and practice into the processes of mathematics teaching development and mathematics teacher education is valuable and important. First, because these processes are of significance for teachers themselves; secondly, because ultimately they have an effect on pupils learning mathematics in classrooms.

Mathematics education research in recent decades has developed a view of knowledge growth in mathematics as occurring through interactions of human beings in a social world. The ways in which such knowledge is treated in the literature is dependent on the associated theoretical perspectives. A constructivist tradition, associated with the work of Piaget and dealing with the construction of mathematical knowledge by individuals within social settings, has been promulgated largely during the 1970s and 80s (Piaget, 1950; Skemp, 1971; von Glasersfeld, 1987; Cobb, Wood and Yackel, 1990; Ernest, 1991; Confrey, 1995; Steffe, 2000). The focus on individual learning in much of this work was challenged by researchers and theorists working in a sociocultural tradition related to the work of Vygotsky and his followers and seeing knowledge as derivative of language, culture, social setting and human interaction (Wertsch, 1991; Bauersfeld, 1994; Bruner, 1996; Lerman, 1996). There is currently much debate about whether these perspectives are incommensurable, or whether it is possible to bridge the theoretical gap (e.g., Jaworski and Kleve, 2000; Kieran, Foreman and Sfard, 2001).

Fundamentally we are concerned with *teachers’* knowledge; however, in trying to elucidate this issue, a first consideration is the learner of mathematics who might be a pupil in a classroom or a pre-service teacher at university, or in a variety of further educational settings. There is an expectation that students in such settings will learn mathematics. It is also of fundamental concern *what* mathematics will be learned and

how. For example, is it sufficient for a student to learn mathematical skills - the algorithms and rules for certain operations, for example - or are we looking for deeper learning in terms of mathematical concepts, relationships, applications and aesthetics? Paradigms of conceptualising knowledge are important, as is mathematical epistemology, and alternative ways of formulating and perceiving mathematics (e.g., Khun, 1962; Lakatos, 1976; Ernest, 1991). The way mathematics is seen, for example, as a *Platonist* construct, a *formalist* process, or a *fallibilistic* enterprise, is believed to underpin ways in which classrooms are constituted, and mathematical activity composed (e.g., Davis and Hersh, 1980; Ernest, 1991; Sanders, 1994). For many teachers of mathematics, such foundations of knowledge and their relations to pedagogy are largely tacit (e.g., Othman, 1995). What is of importance to the teacher is fostering students' growth of mathematical knowledge within some formal educational environment, which includes institutionalised management and curriculum and assessment practices (e.g., Smith, 2001; Othman, 2002). Part of the teacher's responsibility involves creating opportunities for students to interact with mathematics: to deal with mathematical ideas, address mathematical concepts, learn skills, and develop ability to apply mathematical knowledge, as indicated in the National Curriculum document for mathematics (DfEE, 1999a). The fundamental triad of teacher/student/mathematics represents this situation. A slightly different form of this triad replaces student and teacher with the processes of *learning* and *teaching* (i.e., teaching/learning/mathematics) and focuses on ways in which the participants involved engage in these processes. The focus on processes allows us to consider knowledge development without falling into the trap of talking about some people 'developing' others, for example, teacher-educators developing teachers. This can result in a 'deficit' discourse relating pupils or teachers who *lack* knowledge or expertise and thus need remediation (as indicated, for example, by Brown and McIntyre, 1993 and Dawson, 1999).

These considerations are a preamble to exploring questions about teachers' knowledge, the development of that knowledge and ways in which it can be fostered through teacher education practices in order to develop teaching.

The Structure and Content of the Monograph

The monograph focuses on many questions and associated issues relating to the development of mathematics teaching and the education of teachers of mathematics. It focuses on mathematics and its learning only where such considerations relate directly to the development of mathematics teaching and teachers. In organising what is an extensive and complex set of materials we decided on four areas that seemed to make sense distinctly, although there is inevitably overlap and links between them. They are:

- Subject and pedagogical content knowledge for teaching mathematics (Chapter 2).
- Initial teacher education for teaching mathematics (Chapter 3).

- Continuing professional development in mathematics teaching (Chapter 4).
- Developing mathematics teaching through communities of inquiry and critical intelligence (Chapter 5).

Where we speak of teachers' *knowledge*, we include both knowledge of mathematics and knowledge of teaching and learning mathematics. Discussion in Chapter 2 deals with complexities in both of these domains as well as their inter-related nature. For the former, mathematical knowledge and its nature are important, as well as research relating to people's conceptions of mathematics. The latter draws on wide considerations of learning and teaching knowledge, both in and beyond mathematics education. This includes the domains of teacher knowledge identified by Shulman (e.g. 1987) that include knowledge of subject and of pedagogy and of 'pedagogic content knowledge' that relates pedagogy to subject. Included here also are teachers' knowledge and beliefs; thinking and decision-making; teachers' practices and their development; all of which contribute to the processes of learning and teaching in classrooms.

Further, teachers of mathematics are required to develop an 'official' pedagogic discourse in line with the requirements of the formal educational system. These requirements, some statutory and some non-statutory, guide and constrain learning and teaching in both classrooms and initial teacher education. Chapter 3 looks at Initial Teacher Education, beginning with a brief documentary analysis of the way in which successive governments have, since the 1980s, increasingly shaped it into the official discourse now referred to as Initial Teacher Training (ITT). We explore as researchers/practitioners, and importantly teacher educators, our understanding of these last two decades and chart what for us have been the most significant shifts in direction. We identify, for example: theoretical models of ITT; the emergence and changing context of partnership; the attitudes and beliefs of pre-service teachers; the increase in prescription and regulation relating to ITT courses and the assessment of pre-service teachers, and the policing of both by the Office for Standards in Education (OFSTED) - a significant feature of the current ITT *milieu*.

All forms of knowledge cited above develop further, or have the potential to do so, as teachers engage in the complexities of teaching. The development of mathematics teaching by practising teachers has been formalised in a variety of ways, and is currently gathered under a general heading of Continuing Professional Development (CPD) and we address this in Chapter 4. The term tends to be applied to teachers rather than teaching, and hence can result in the deficit discourse mentioned above. Teacher educators work with teachers in a variety of modes and situations, aiming to engender more 'effective' practices at all levels. (By 'effective' here we include practices whose outcomes are successful in fostering students' mathematical learning, their enjoyment of mathematics and their ability to use and apply mathematics in a variety of contexts. We recognise the complexity of these ideas and address the notion of 'effectiveness' further below.) Providers of CPD include Higher Education Institutions (HEI), Local Education Authorities (LEA), independent consultants and

other teachers. Activities include courses, workshops, conferences, classroom and research or inquiry-based developmental activity. This latter activity has become the grounding for an increasingly important strand of CPD and often results from partnerships between practitioners and teacher educators/researchers in a variety of modes at a variety of levels.

We develop and elaborate the notion of ‘inquiry’ in Chapter 5. Research-based teaching development relates to notions of ‘communities of inquiry’ or ‘critical intelligence’, where all participants in the educational system are regarded as researchers in a mutual learning enterprise. Notions of inquiry raise important questions for this monograph and indeed for teachers, teacher educators and researchers regarding the *nature* and *forms* of knowledge. Such essential epistemological questions are explored in the Epilogue to this monograph, Chapter 6, which also takes up the key issues emerging from earlier chapters.

Monograph Review Methodology

We conclude this Prologue with an account of the methodology that we adopted in producing this monograph. The origins of the monograph (see Preface) as an inquiry by FRAME Group 3, focused upon *Mathematics Teaching and Teachers’ Professional Education and Development*, determined that we began with three key research questions:

1. What do we know in this area?
2. What do we still need to know?
3. What are the key research questions?

As our ‘practitioner inquiry’ developed we added two further questions:

4. What is current practice and how is it situated historically?
5. What are the key issues in theory-practice relationships, and what do they indicate for future practice?

In reviewing research and other theoretically-based literature pertaining to questions 1 and 4 ‘What do we know?’ and ‘What is current practice and how is it situated historically?’ we trawled data bases including BEI, ERIC and the Social Science Citation Index. We also reviewed the contents pages and hand-searched the content of journals in the areas of teacher education and professional development, with a particular focus on mathematics teacher education. Using the ‘mathematics-education’ e-mail discussion list maintained by Peter Gates at Nottingham, we solicited information concerning research (including local, possibly unpublished initiatives) on the initial training and continuing development of mathematics teachers. In addition we asked other teacher educators and researchers what issues they perceived to be significant. This consultation process included two 1-day conferences, in London and in Manchester, involving some 60 colleagues, who submitted about 20 short issues-based review/summary papers, most of which have

been assimilated in this monograph. Ongoing electronic communication was established with a wider group of individuals as a result of these day conferences. Finally, we benefited from eight reviews of the whole document, or selected chapters, as part of the BSRLM review process. We included virtually all the suggestions offered in these reviews. This process, as well as identifying some additional material thought useful to include in Chapters 2, 3 and 4, also further informed our thinking regarding Chapter 5.

The protocol that we use for the selection of research and theoretically based literature was that it should:

- have been published within the last twenty years;
- have been published in a peer reviewed journal or academic book;
- relate to, or be thought to be directly applicable to, the UK context.

The protocol that we used to select examples of practice was that they should:

- have taken place within the last twenty years;
- relate to the UK context.

On a small number of cases, we chose to depart from these protocols. For example, certain aspects of Japanese and Chinese teachers' professional lives (described in Chapter 4) are not reflected in the UK scene, yet they provide a model of teaching development that usefully grounds the focus on inquiry in Chapter 5.

We make the distinction in this protocol between research and theoretically based literature. It was not within the scope of this inquiry to consider the soundness or the nature of the methodology of research-based literature and in particular of studies that claimed an empirical research base. We considered this function to have been accomplished, to a degree, in the peer review process. Additionally, as a 'professional' rather than 'academic' review (Bassey, 2001) our remit was such that we set out to identify reports of research and practice, but not to assess them systematically (see also Hammersley, 2001). In relation to theoretical literature, much that we have included was originally grounded in a robust empirical base, such as Shulman's categories of Teacher Knowledge. In the cases where the empirical base was not overt we included particular treatises where we felt that the insights afforded augmented and were valuable to the thesis we were developing.

As a final methodological point, we briefly address the notion of *effectiveness*. At the day conferences, particularly the London conference, the problematic nature of the term 'effective' emerged as a significant issue in discussion. At various times in this monograph, we find ourselves almost unable to avoid using the term in relation to 'effective' learning, 'effective' teaching of mathematics or 'effective' programmes of teaching development. The term 'effective' is typically used in an imprecise or undefined way, yet it can have considerable rhetorical force in its assertions. To suggest that an approach to, for example, teaching or management is 'effective' is

Developing Mathematics Teaching and Teachers

often sufficient to commend it. When we use the term in this document we report it in the form, and with the meaning, indicated by the researchers who employ it. Thus, for example, Askew, Brown, Rhodes, Wiliam and Johnson (1997b) define the 'effectiveness' of teachers of numeracy in terms of average pupil learning gains within a school year. The Teacher Training Agency, on the other hand, defines the 'effectiveness' of pre-service teachers in terms of the standards listed in DfEE (1998a) Circular 4/98 (or 2/02 from September 2002). Sometimes, when the term 'effective' is employed in the literature its specific meaning is not explicitly defined. Given the extreme diversity of research contexts and purposes, definitions of effectiveness related to teaching and learning need to be situated both locally and temporally; the term should be defined explicitly or characterised clearly in order to determine when it is being achieved and to what extent, and to make clear the criteria being associated with it. On occasions in the literature where this is not the case, we do not attempt to suggest or impose fixed or global meanings to the word.