RECENT UK RESEARCH INTO PROSPECTIVE PRIMARY TEACHERS' MATHEMATICS SUBJECT KNOWLEDGE: A RESPONSE

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In this paper, I respond and comment on the papers presented at the colloquium, Recent UK Research into Prospective Primary Teachers' Subject Knowledge. I draw out themes arising from the six presentations, in the context of other related research in the UK and elsewhere. I conclude by raising a series of issues and questions for future work in this area.

INTRODUCTION

The six presentations within this colloquium all report on research set in the context of a statutory mathematics subject knowledge audit within primary initial teacher education (ITE) (DfEE, 1998). The authors discuss responses to the use of a formal audit, self-auditing by trainees themselves and initiatives arising from this auditing process directed at improving student teachers' knowledge of mathematics. Recent guidance has shifted the emphasis away from pencil and paper tests and towards the assessment of mathematical knowledge through student teachers' classroom practices (Teacher Training Agency, 2003). Hence, this is an important and timely opportunity to evaluate this work and to consider the impact this focus on mathematics subject knowledge has had on ITE courses in England and Wales.

Subject knowledge in primary mathematics has been recognised as an issue for some time within the mathematics education community (e.g., Ball, 1990), at a policy level in the UK (e.g., Alexander, Rose, & Woodhead, 1992; OfSTED, 2001) and anecdotally by those of us who regularly observe in primary classrooms. Many primary teachers appear to have significant gaps and weaknesses in their mathematical knowledge. Yet the issue is more than one of simply ensuring teachers have "more" mathematics. Indeed, Askew et al (1997) found that increased academic qualifications in mathematics to be slightly negatively associated with effective mathematics teaching[1]. Nor is the problem amenable to a "quick fix" solution. In the 5 year Leverhulme Numeracy Research Programme, for example, Brown et al (2003) found little evidence that the relatively substantial interventions associated with the National Numeracy Strategy have had qualitatively significant effects on teachers' subject knowledge.

Several of the papers refer to the recent study by Ma (1999), who sought to understand how Chinese pupils outperform US pupils in international comparative

[1] Askew et al (1997) found the teaching of teachers who had studied mathematics A-level to be similar to the teaching of those who had not studied A-level. When they considered the teachers who had passed A-level there was a slight negative effect, although this was not statistically significant.

tests despite Chinese teachers generally lower academic qualifications in mathematics. Ma compared a group of Chinese elementary teachers, who were mathematics specialists but who had not studied mathematics beyond the age of 14, with a group of US generalist elementary teachers, who had studied mathematics at college level. Ma found that the distinguishing feature of the Chinese teachers was their attitude to and understanding of mathematics. Indeed, some of the Chinese teachers in her study appeared to have an extremely deep knowledge, something she defined as a Profound Understanding of Fundamental Mathematics (PUFM). Ma's study has been important in highlighting the possibility of primary teachers developing a deep understanding of mathematics. It has been so influential that Johnny Lott, in his capacity as President of the US National Council of Teachers of Mathematics, has recently called for elementary mathematics specialists citing Ma's study as evidence (Lott, 2003). It is arguable, however, that the crucial factor in the Chinese teachers' profound subject knowledge was not their specialist focus so much as their own mathematical experiences at school and their attitude to their own professional development. Ma's work usefully adds to the literature highlighting the need for primary teachers to know mathematics differently. However, unlike the studies discussed here, Ma's work was conducted with practising teachers and focussed almost exclusively on number.

THEMES

Mathematics subject knowledge is more than number

In the current instrumentalist policy climate within mathematics education, several of these studies are useful reminders that teachers need to know more than just number and numeracy. Mooney, Fletcher & Jones focus on the trainees' knowledge of geometry and probability, whilst Goulding and Rowland, Martyn, Barber & Heal highlight the areas of reasoning and proof. They thus provide an important counter to the almost exclusive focus on number and proportional reasoning in existing research and in UK policy agenda (e.g., OfSTED, 2001). In contrast to Ma's (1999) argument that division by fractions to be the most difficult aspect of the primary mathematics curriculum, Goulding found that trainees' subject knowledge of geometry to be particularly weak.

Audits have focused attention on teachers' mathematics subject knowledge

The studies here highlight positive and potentially valuable ways in which the authors and their ITE institutions have responded to the issue of weak subject knowledge amongst their trainees. It is certainly arguable that without the auditing requirement the recent focus on subject knowledge would have been very much less intense. Murphy, however, highlights the tension inherent in this process with students perceiving the audit as both a valuable "filling gaps" exercise and as a less relevant "hoop jumping" exercise.

The interconnection between mathematical knowledge and effective teaching

Rowland, Martyn, Barber & Heal add weight to their earlier finding of a positive relationship between students' subject knowledge (as assessed by the subject knowledge audit) and their teaching competence, although the findings of Rowland, Huckstep & Thwaites at a different institution were more equivocal (Rowland, Martyn, Barber, & Heal, 2000). It is perhaps worth reflecting that such a finding does not contradict the work of Askew et al (1997) discussed above, since the subject knowledge audit was a very different test to A-level and the audit (unlike A-level) was conducted during the course. Mooney, Fletcher & Jones point to the importance of developing student teachers' process knowledge. They discuss the use of some non-standard (and relatively difficult) problems within an audit, which encouraged students to use and question their intuitive knowledge of mathematics.

Enabling primary teachers to develop their mathematical knowledge

Goulding and Mooney both discuss the effects of the self-audit process on the trainees finding it to have some positive effects. Goulding, for example, found the students' subject knowledge had improved in areas they themselves had identified as a weakness. However, the trainees were less able to identify their own weaknesses in the more content-free area of mathematical reasoning and proof and perhaps as a consequence these areas showed less improvement in the final subject knowledge audit. A further issue that Goulding highlights in relation to reasoning and proof is the need to convince students of the relevance of non-elementary mathematics for the teaching of primary mathematics. Mooney makes a similar point in relation to a small number of Key Stage 1 specialists.

Barber, Heal & Martyn discuss a peer-tutoring approach pairing students with stronger subject knowledge alongside students with weaker subject knowledge. This builds on the Vygotskian notion of peer mediation, although the intervention described here (one 3 hour session) seems somewhat limited to have a significant effect on trainees' mathematics subject knowledge. Nevertheless the students themselves perceived the process as a useful one and it appeared to reduce mathematics anxiety amongst the trainees.

Rowland, Huckstep & Thwaites discuss the assessment of trainees' subject knowledge in the context of their classroom practice and develop an instrument that appears to have potential use for formative assessment. In particular, they point to the importance of the *transformation* of subject knowledge *for oneself* into a knowledge that can enable other *to learn.* They also usefully highlight the *contingent* nature of teaching and hence the complexity of the way teachers use subject knowledge in their teaching decisions.

ISSUES AND QUESTIONS

Confidence, anxiety and emotion

Several of these papers discuss the issue of mathematics anxiety and the need to increase trainees' confidence. The problem of maths anxiety is well documented (e.g., Buxton, 1981). However, simply reducing anxiety and enabling teachers to "feel better" about mathematics can lead to complacency as Askew (1996) found in the evaluation of the National Curriculum. Rowland, Huckstep & Thwaites quote Brown & Wragg in relation to teaching: "Our capacity to listen diminishes with anxiety." However, I would argue that our capacity to listen is only possible through an intellectual *and* emotional engagement with mathematics. Such intense engagement can be at times both painful and difficult. Like primary teaching, mathematics is an emotional, intuitive and complex activity; mathematicians, like primary teachers, do what they do because they enjoy it and despite the difficulties. One criticism of Ma's (1999) Chinese teachers is that the mathematics they present appears overly formal and deductive. In this regard, Bibby and myself have argued for the importance the desire to teach mathematics (Bibby & Hodgen, 2003).

What is "good enough" mathematics knowledge?

Mooney, Fletcher & Jones tackle the important question of what mathematical knowledge is sufficient and realistic for generalist teachers at the beginning of their teaching careers. They argue for a mathematical knowledge equivalent to the mathematical proficiency described in the US "Adding it up" report (Kilpatrick, Swafford, & Findell, 2001). This issue of good enough knowledge is an important one, particularly in relation to teachers who teach mathematics alongside nine other National Curriculum subjects. Nevertheless, Mooney et al's pragmatic answer is problematic in two ways. Firstly, Kilpatrick's mathematical knowledge is still at a very high level, very much higher than that we currently expect of our primary NQTs (and experienced teachers). Secondly, this underplays the importance of pedagogical content knowledge. Teachers use mathematical knowledge not so much for the *doing* of mathematics but rather for the *teaching* of mathematics, the transformative and contingent aspects that Rowland, Huckstep & Thwaites point to. Hence, a key aspect of primary teachers' mathematics knowledge, even at an early stage in their teaching career, needs to be the teacherly transformation of content knowledge into knowledge *sufficient* for the teaching of mathematics.

Initial Teacher Education is only the beginning

Rowland, Martyn, Barber & Heal argue that it would be more honest and realistic to view the process of developing mathematics subject knowledge as an "on-going professional process." Ma's (1999) teachers developed over the careers. One striking feature of Ma's study are the ways in which the Chinese teachers view their own mathematical knowledge as "work in progress". Indeed the teachers with a profound understanding had an average of 18 years of teaching experience. This leads to the question of how we can enable primary teachers to see themselves as learners of mathematics *and* mathematics education in similar ways to Ma's Chinese teachers. It is arguable that ITE is likely to be less influential in this process than teachers' on-going professional development experiences.

To what extent are subject knowledge audits a useful tool?

The papers presented here largely focus on an individual and decontextualised audit of mathematics knowledge. Two of the papers explore collaborative approaches to developing subject knowledge: in developing their formative assessment tool, Rowland, Huckstep & Thwaites usefully point to the situated nature of teachers' knowledge in terms of classroom decisions, whilst Barber, Heal & Martyn point to the possibility of trainees working together to develop their subject knowledge.

There is increasing evidence that teachers' subject knowledge is both situated and distributed (see e.g., Putnam & Borko, 2000). Work in the Leverhulme Numeracy Research Programme at King's College suggests that some schools successfully "share" mathematics knowledge and expertise amongst a group of teachers. In my own research, I have found that primary teachers exhibited a far deeper and more substantive subject knowledge when working with others on authentic tasks than in individual "test" settings (Hodgen, In preparation; see also Hodgen, 2003). This would suggest that, despite the appearance of rigour, individual tests may not be as valid or reliable as more collective audits or assessments of subject knowledge.

CONCLUSION

The papers in this colloquium are evidence of a vibrant and valuable debate and research on the very real and complex issue of teachers' mathematics subject knowledge. I look forward to further discussions arising from this work.

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