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Relationships between teachers' background, their subject knowledge and pedagogic efficacy, and pupil achievement in primary school mathematics in Hong Kong: An indicative study

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ABSTRACT

This study investigates how teacher background, subject knowledge and pedagogic efficacy affect Grade 4 children's (aged 9–10) mathematical achievement in 10 primary schools in Hong Kong. Mathematics teachers were selected for their strong commitment to teaching mathematics and their pupils' consistently high international mathematics performance. Teacher measures (i.e. level of mathematics education, teaching experience, mathematics subject knowledge, performance in mathematical operations and pedagogic efficacy) were checked for factor consistency and assessed against age-appropriate pupil mathematical achievement. The results showed that teachers were secure in their subject knowledge, and that such knowledge was related to their performance of mathematical operations, but it was high levels of pedagogic efficacy and the ability to perform age-appropriate mathematics operations (rather than subject knowledge) that positively affected their pupils' achievement. These findings contradict ongoing international calls for the enhancement of primary school teachers' mathematical subject knowledge, as they show pedagogic efficacy to be more strongly associated with pupil achievement.

1. Introduction

Concerns about the relationship between teachers' mathematical subject knowledge and pupils' performance have been expressed internationally over the past four decades. These concerns raise questions of policy and practice, and their underlying premise is that greater subject knowledge amongst mathematics teachers will improve children's mathematical understanding and achievement (e.g. Ofsted, 2000; US DoE, 2008). Worries over children's mathematics performance have

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been exacerbated by: 1) international comparisons of such performance that show the gradual decline of Western countries in relation to Asian countries (Henderson, 2012; Mullis, Martin, Fay, & Arora, 2012; OECD, 2010); 2) international curricular recommendations to enhance children's mathematical engagement and achievement by moving, for example, from the traditional transmission teaching approach to inquiry-oriented learning (Ball, 1988; NCTM, 1989; Yates & Collins, 2010); and 3) the realisation that pupils' mathematics achievement may also be affected by their teachers' pedagogic efficacy and associated classroom actions (Ross, Hogaboam-Gray, & Gray, 2003; Stipek, Givven, Salmon, & MacGyvers, 2011).

In the quest to improve primary school children's mathematical engagement and achievement, one frequently cited assumption is that teachers' mathematics subject knowledge is key to such improvement (Aubrey, 1997; Ball, Hill, & Bass, 2005; Goulding, Rowland, & Barber, 2002; Ma, 1999; Ofsted, 1994, 2000; US DoE, 2008). Research has addressed the issue of teachers' subject knowledge through explorations of the level of mathematical training they received in their own secondary and tertiary education (Ball, Lubienski, & Mewborn, 2001; Henderson & Rodrigues, 2008; Hill, Rowan, & Ball, 2005), training to increase mathematics knowledge via pre-service courses and testing (Brown, McNamara, Jones, & Hanley, 1999; Henderson, 2012) and in-service training (Wilkins, 2008). Yet, as Hill et al. (2005),Wilkins (2008) and others have recognised, there are no studies actually showing a direct relationship between teachers' mathematical subject knowledge and their pupils' mathematical achievement. The absence of such a relationship points to the need for further research and more sophisticated arguments concerning other teacher-based factors that may also promote children's mathematical achievement, such as amount of mathematical training, teaching experience, pedagogic efficacy and actions/interactions in the classroom (Ma, 1999).

2. Background of the study

The setting for this study was Hong Kong (HK), where mathematics teachers have been encouraged to move away from didactic teaching methods (CDCHK, 2000) and schoolchildren score consistently highly in mathematical understanding in international assessments (Mullis et al., 2012; OECD, 2010). Its data were taken from a larger-scale quasi-experimental project that investigated the promotion of children's mathematical understanding via an enhanced social pedagogic teaching intervention.[1] Five hundred and four pupils and twenty primary school mathematics specialist teachers in HK formed the sample. Each of the teachers involved had expressed interest in improving their classroom skills and volunteered to participate in the research (refer to *The Present Study* section below for further information on the teachers' background). Data were collected to elicit the teacher self-reported characteristics identified by Rowland, Martyn, Barber, and Heal (2001), including teachers' mathematics subject knowledge, level of mathematical training undertaken prior to becoming a teacher, number of years teaching mathematics, performance confidence in undertaking age-appropriate mathematical operations and age-appropriate pedagogic efficacy (i.e. confidence in teaching mathematics topics associated with pupils' learning engagement). These data provided the criteria for assigning teachers/classes to experimental and control groups in the larger-scale project, and allowed us in the present study to assess whether pupil mathematics achievement in HK varies across classrooms and to seek explanations for such achievement based on a range of teacher characteristics.

3. Theoretical framework

Since the 1980s, educational policy in a number of countries has increasingly become concerned that primary school teachers' limited mathematical subject knowledge is responsible for their pupils' low levels of mathematical achievement (Ma, 1999). Concern over the teacher subject knowledge-pupil achievement link prompted Shulman (1987) to develop terminology for different types of self-reported teacher knowledge in the education context. Whilst not referring to mathematics per se, Shulman differentiated amongst subject matter knowledge (SMK), pedagogic content knowledge (PCK), curriculum knowledge (CK) and five other aspects of knowledge used for teaching. Drawing upon this vocabulary, a number of studies focusing on the mathematics curriculum have been undertaken in an attempt to link SMK (often supported by PCK) to pupils' mathematical achievement (Ball et al., 2005; Goulding et al., 2002; Ma, 1999; National Commission on Teaching and America's Future, 1996; Ofsted, 1994; US DoE, 2008; Ubuz & Yayan, 2010; Wong, Rowland, Chan, Cheung, & Han, 2008). Although a rather simplistic relationship between teacher SMK and pupil performance has been posited, the results of international studies have been ambiguous. For example, Askew, Rhodes, Brown, William, and Johnson (1997), Hill et al. (2005) and Ma (1999) failed to document a direct relationship between SMK and pupil achievement, although they noted that low levels of SMK are associated with poor pupil performance in mathematics. Further, Muijs and Reynolds (2002) suggested that a curvilinear relationship might exist between SMK and performance, with both low and high levels of SMK associated with poor pupil performance.

Studies investigating the issues of teachers' self-beliefs, pedagogic activity and classroom activity have further indicated just how problematic the proposed SMK-performance relationship is (Henderson, 2012; Hill et al., 2005; Muijs & Reynolds, 2002). Research shows that teachers who lack specific aspects of SMK may avoid teaching specific topics or may teach them using traditional/transmission techniques (Cunningham & Blankenship 1979; Goulding et al., 2002; Ofsted, 1994, 2000;

[1] The project was a collaborative effort between two research teams in the University of Cambridge and one of the universities in Hong Kong, which involved 13 academic scholars and research assistants in both places participating in a variety of research activities such as teacher training workshops and classroom observations. It was supported by the Economic and Social Research Council (UK) and Research Grants Council (HK) joint-funding scheme.