Teaching and Teacher Education 49 (2015) 97–107

Contents lists available at ScienceDirect

Teaching and Teacher Education

journal homepage: www.elsevier.com/locate/tate

Changing perspectives: Examining the potential for advanced mathematical studies to influence pre-service teachers' beliefs about mathematics☆

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HIGHLIGHTS

- Discusses challenges of changing beliefs about mathematics to support reform.
- Considers potential for mathematical studies to impact beliefs about mathematics.
- Demonstrates persistence of old beliefs through advanced mathematical studies.
- Evidence of potential for mathematical studies to impact beliefs about mathematics.

ARTICLE INFO

Article history:
Received 19 April 2014
Received in revised form
2 March 2015
Accepted 6 March 2015
Available online 11 April 2015

Keywords:
Mathematics
Teacher beliefs
Mathematics teacher education

ABSTRACT

This study considers the potential for advanced mathematical studies to impact pre-service teachers' beliefs about mathematics. Results show that, after completing a degree which includes advanced mathematical studies, many prospective teachers' beliefs still reflect limited interpretations of key terminology and do not value the theoretical and conceptual network underpinning the rules and procedures of secondary mathematics. Many of their beliefs about the nature of mathematics also fail to recognise its capacity to stimulate analytical thought and creativity. In cases where pre-service teachers showed evidence of well-developed beliefs, the study explores the role of their advanced mathematical studies in this development.

1. Introduction

The relationship between teachers' beliefs about mathematics and their classroom practice has been a focus of international research within the field of mathematics teacher education for several decades (Beswick, 2012; Cooney, 1985; Leatham, 2006; Pehkonen, 1999). Evidence linking teachers' beliefs about mathematics to their choices regarding planning, teaching and assessment has important implications for mathematics teacher education. Hart (2002) makes the case that a critical mission for mathematics teacher education is to align teachers' beliefs about mathematics with the desired philosophy, aims and objectives of the educational system in which they are preparing to teach.

> There is substantial evidence that teachers' beliefs about mathematics impact their teaching of mathematics. Given this evidence, it is appropriate that teacher education programs assess their effectiveness, at least in part, on how well they nurture beliefs that are consistent with their philosophy of learning and teaching (p.4).

With this in mind, this article focuses specifically on considering the effectiveness of a sequential model of initial teacher education (ITE), with regard to shaping the beliefs of its future mathematics teachers. In a sequential model of ITE, secondary teachers earn their qualification through the completion of a primary university degree followed by a postgraduate ITE programme. The structure of this model relies heavily on the prospective teachers' studies of mathematics in their primary degree for progressing their knowledge and beliefs about mathematics, in preparation for teaching.

☆ This article is based on a broader study conducted by the author for the doctoral dissertation – What they really think: A study of the beliefs of prospective second-level mathematics teachers in the Republic of Ireland.

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http://dx.doi.org/10.1016/j.tate.2015.03.002
0742-051X/

This article examines pre-service teachers' qualitative reflections on their advanced studies of mathematics in their primary degrees, with the aim of considering whether these studies have contributed to aligning their beliefs about mathematics with the philosophies of the education system in which they are preparing to teach. While the study is set in the context of mathematics education reform in Ireland, the theoretical background on teachers' beliefs, the issues raised and the implications of the results can be positioned within a larger international discussion regarding the value of advanced mathematical studies for mathematics teachers and improving the effectiveness of mathematics teacher education.

2. Beliefs about mathematics and their impact on practice

Many definitions, theories and frameworks offered by researchers have framed discussions regarding teachers' beliefs for over 25 years. In one such theory, Ernest (1989) identifies the two key components of mathematics teachers' beliefs as their conceptions of the nature of mathematics and views or models of mathematics teaching and learning. Research on these beliefs is encompassed within a large interdisciplinary body of research on epistemological beliefs (beliefs about knowledge and knowledge acquisition); however, because the term epistemological beliefs can be so broadly interpreted and widely inclusive (Schoenfeld, 2002), this article will specifically focus on beliefs about the nature of mathematics.

While concerns have arisen about inconsistencies in efforts to link teachers' beliefs about mathematics teaching and learning with classroom practice (Cooney, 1985; Hiebert, Morris, & Glass, 2003; Li & Yu, 2010), there is more compelling evidence linking teachers' practice with their beliefs about the nature of mathematics. In fact, many researchers point to teachers' beliefs about the nature of mathematics as the greatest indicator of how they teach it (Ball & Bass, 2004; Beswick, 2012; Cohen, 1990). When asked about how mathematics should be taught, teachers may use language and buzz words that reflect an awareness of current trends and recommended practice; however, unless their beliefs about the nature of mathematics support teaching the subject in these ways, such approaches will not be reflected in their practice (Leatham, 2006; Raymond, 1997).

In fact, Ernest (1989) presents a model in which teachers' views of the nature of mathematics are positioned as the basis for their mental models of mathematics teaching and learning, which, in conjunction with social context and external constraints, inform their practice. Similarly, Thompson (1992) links teachers' conceptions of mathematics with their "mental images and preferences concerning the discipline" (p.132). Both emphasise that a teachers' views and conceptions of the nature of mathematics influence how they engage with the subject both during their own mathematics education and in their role as mathematics teachers.

Viholainen, Asikainen, and Hirvonen (2014) offer a review of different theories and perspectives which categorise beliefs and philosophies regarding the nature of mathematics. In each case, clear implications for mathematics teaching and learning are established for the respective beliefs. Among these are Ernest's (1989) three philosophical views of the nature of mathematics – instrumental, Platonist and problem solving. An instrumental view of mathematics sees it as a "set of unrelated but utilitarian rules and facts; " a Platonist view sees mathematics as "a static and unified body of knowledge that is discovered, not created; " and a problem solving view sees mathematics as "a dynamic, continually expanding field of human creation and invention" and "a process of enquiry and coming to know, not a finished product" (p.250).

Researchers have also shown that teachers' own understanding of mathematics can be both motivated and constrained by their beliefs about the nature of the subject, and vice versa. Schoenfeld's (1992) characterisation of beliefs includes "understandings and feelings that shape the ways that the individual conceptualizes and engages in mathematical behaviour" (p. 358). Consequently, Cohen (1990) shows that if a teacher's own notion of what constitutes mathematical understanding is limited, this will restrict the depth of learning that is promoted in his or her classroom.

Beliefs about the nature of mathematics which lack depth and conceptual understanding are related by both Dossey (1992) and Thompson (1992) to the first level of Perry's (1970) hierarchical scheme of intellectual development – *the dualistic stage*. At this level of intellectual development, actions and decisions are governed by fixed rules, and outcomes must be either right or wrong. Teachers with mainly dualistic views of mathematics are likely to believe that their primary responsibility is to present the material to their students and their primary goal is to ensure that their students can perform tasks or procedures required to complete homework and exams (Cohen, 1990; Dossey, 1992; Thompson, 1992).

Dualistic beliefs often result from traditional approaches to teaching mathematics. Putnam, Heaton, Prawat, and Remillard (1992) criticise traditional approaches for reinforcing an "overly rigid and narrow view of mathematics as a static and bounded discipline, composed primarily of procedures to be practiced and learned" (p. 216). Such views are not an uncommon result of secondary education. Pehkonen (1999) explains that university professors have come to expect the following:

> … the typical student will think [university] mathematics is very abstract, will not understand quickly, will consider that mathematics does not make sense, will learn through memory, will not relate mathematical ideas, will not have confidence, will only solve problems to get through the course, will show anxiety, will fear the unexpected, and regard correct answers as the most important thing (p. 391).

Without direct intervention, teachers whose own mathematics education can be characterised as traditional are likely to have conceptions of mathematics that never develop beyond a basic, dualistic level. If future teachers begin their university studies with the beliefs described above, it falls upon their higher education and ITE programme to foster any desired changes.

3. Beliefs and reform

Identifying and addressing the challenges of preparing teachers to progress education in new directions has been, and continues to be, an active conversation among researchers, throughout the world. Despite differing opinions among researchers regarding the strength of the connection between teachers' beliefs and their practice, realigning well-established beliefs to support changes in curriculum and practice is far from straightforward.

Leatham (2006) describes the complex nature of a person's 'belief system' and warns against attempts to target changes in specific beliefs. He relates a belief system to an intertwined raft, in which all of the pieces fit together and support each other. Similarly, Cohen (1990) describes teachers' beliefs as analogous to a fabric made up of tightly woven threads. Both images emphasise the challenges of altering individual beliefs that are entwined in a complex, well-integrated system.

Research on the concept of epistemological world views also cautions against the expectation that changing particular beliefs will translate into changes in teachers' practice. Schraw and Olafson (2002) emphasise that any effort to change teachers' practice needs to consider both teachers' epistemological beliefs and