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Greek-Cypriot elementary teachers' epistemological beliefs about mathematics☆

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HIGHLIGHTS

- Mathematics teachers' beliefs are culturally conditioned.
- Epistemological beliefs about the nature of mathematics.
- Elementary teachers in the Republic of Cyprus.
- Qualitative collective case study.
- Uncovers the cultural specificities of elementary teachers' epistemological beliefs about mathematics.

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ABSTRACT

Drawing on data from the Republic of Cyprus, this paper uncovers elementary teachers' epistemological beliefs about mathematics. Twenty-two experienced teachers were invited to individual semi-structured interviews. Thematic data-driven analyses identified three themes and eight sub-themes, which I discuss, taking their socio-cultural context into consideration. This study suggests that applying predetermined frameworks directly taken from the literature when examining teachers' epistemological beliefs in mathematics can be problematic, as they might hinder other culturally specific beliefs from emerging. In closing, this paper presents some implications for the results on teacher education and professional development, as well as ideas for future research.

1. Introduction

For more than thirty years, mathematics teachers' beliefs and their relationship to instructional practices have been put under the microscope, based on the assumption that the latter constitute manifestations of what one believes about the nature, the teaching, and the learning of the subject (see, for example, Chapman, 2002; Ernest, 1989; Raymond, 1997; Skott, 2013; Thompson, 1984). In acknowledgement of the definitional inconsistencies (Pajares, 1992; Törner, 2002) regarding the notion of beliefs (a term often used interchangeably with similar ones, like attitudes, conceptions, views, images, perceptions and so on), here I follow da Ponte (1994), who argues that "[b]eliefs are the incontrovertible personal 'truths' held by everyone, deriving from experience or from fantasy, having a strong affective and evaluative component" (p. 199). As such, comment Aguirre and Speer (1999), mathematics teachers' beliefs shape practice and orient knowledge. Beliefs are typically nested in clusters called *belief systems* (Op't Eynde, De Corte, & Verschaffel, 2002; Törner, 2002) or as *organising structures*, according to Thompson (1992). These systems are not necessarily logically structured, making it possible that an individual may hold beliefs that are incompatible or inconsistent (Andrews & Hatch, 2000; Richardson, 2003).

I shall not engage here in a detailed account of the nature of mathematics-related beliefs in general, as this would go beyond the scope of this paper.[1] Exploratory in nature, the purpose of this paper is to examine Greek-Cypriot elementary teachers' epistemological beliefs about mathematics. Epistemological beliefs, a

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[1] For more on this, see the work of authors like Ernest (1989), Mason (2004) and Pajares (1992).

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particular type of beliefs, are concerned with the nature and source of knowledge (Perry, 1970) and vary significantly across disciplines (Schommer-Aikins, Duell, & Barker, 2003). In mathematics education research, while the relationship between teachers' general beliefs and their instructional practices is seen as complex and cannot be described in terms of cause-and-effect (Beswick, 2005; Raymond, 1997; Skott, 2013; Thompson, 1984), mathematics teachers' epistemological beliefs have been found to have significant connections with teaching efficacy beliefs (Chrysostomou & Philippou, 2010; Ertekin, Dilmaç, Yazıcı, & Peker, 2010) and are seen as strong predictors of one's instructional choices (Beswick, 2012; Garegae, 2016; Leung, 2006). Comparable observations have been made from pupils' perspective, whose epistemological beliefs appear to have a great impact on their attainment in mathematics (Garofalo, 1994; Rastegar, Jahromi, Haghighi, & Akbari, 2010). It is, therefore, not surprising that many recent studies in the field of mathematics teacher education have been designed to help participants enhance their epistemological beliefs (i.e. Charalambous, Panaoura, & Philippou, 2009; Schommer-Aikins, Unruh, & Morphew, 2015; Viholainen, Asikainen, & Hirvonen, 2014; Zakaria & Musiran, 2010).

The focus of this paper is on experienced in-service elementary teachers in the Republic of Cyprus and on their epistemological beliefs about mathematics. More specifically, the initial aim of the analysis process was to provide answers to the following research question: What epistemological beliefs about mathematics are held by experienced in-service elementary teachers in the Republic of Cyprus? After the completion of data analysis, this initial question was refined and broken down into three more specific questions: (1) According to teachers' beliefs, what *is* mathematics? (2) What are teachers' beliefs about how mathematical knowledge can be verified and how we come to know it? (3) What other epistemological beliefs are held by the teachers that do not fall under any of the first two research questions? In the second question, "how we come to know it" refers to the process(es) of internalisation of mathematical knowledge in individuals and/or groups of people. An alternative phrasing would be "how do we know what we know". A retrospective revision of questions is very common in qualitative studies, in which the ongoing process of posing, revisiting, and revising the initial questions has a central role in understanding and uncovering the perspectives of others (Agee, 2009; van der Vaart, van der Zouwen, & Dijkstra, 1995).

Before I discuss the findings of this study, I will turn to the wider international literature and consider both the philosophical question about the nature of mathematics and the research on mathematics teachers' epistemological beliefs, with an emphasis on how various models categorise such beliefs. These theoretical considerations are important for positioning my work in the international research dialogue, through the presentation of a Greek-Cypriot perspective. Subsequently, the findings of this study are discussed, and some implications and suggestions for future research are provided.

2. Theoretical considerations

Epistemological questions about mathematics are expressed and examined by both professional mathematicians and philosophers, with the former typically engaged in *foundational research*, while the latter contribute to the *philosophy of mathematics* (Horsten, 2016). Such enquiries are not new. In fact, the first discussions in this area date back to the fourth century BC and are attributed to Plato and Aristotle (Dossey, 1992). For Plato, mathematical objects had an existence of their own, where clear lines distinguished the ideas of the mind and their representations, as perceived by the senses. On the contrary, Aristotle, a student of Plato, perceived mathematical ideas as idealisations performed by the mathematician, as a result of experience with objects. These two schools of thought later became associated with absolutist and fallibilist standpoints, respectively (Ernest, 1991). On the one hand, absolutism perceives mathematical knowledge as a body of knowledge that contains absolute, certain, and unchallengeable truths; and, fallibilism, on the other, sees mathematical knowledge and truth as corrigible. The "absolutism *vs* fallibilism" debate was intensified with the work of contemporary philosophers of mathematics, like Imre Lakatos (1976) and Thomas Tymoczko (1986), both members of the fallibilist school. As a consequence, more elaborate paradigms emerged (i.e. namely logisism, symbolism, intuitionism, quasi-empiricism, and so on) to secure the foundations of mathematics (Handal, 2003). Subsequently, alternative paradigms have been proposed, as, for example Ernest's (1991) social constructivism and Lakoff's and Núñez's (2000) theory of embodied mathematics. Further discussion on various paradigms, however, would fall outside the remit of this paper. It is important to note from the above that each paradigm has a different position on what mathematics *is* and where it comes from, and that even in the circles of professional mathematicians, various epistemological opinions are held (Ernest, 1999). As a result, this diverse mixture of conceptions about the nature of mathematics has influenced the ways researchers in mathematics education, school teachers, and the general public see the teaching and learning of mathematics (Dossey, 1992). Yet, many scholars highlight how there are notable differences between professional mathematicians' and school teachers' (both primary and secondary) ways of working with mathematics (i.e. Beswick, 2012; Boaler, 2008; Dörfler, 2003; Ernest, 1991). As Boaler (2008) points out, "[t]he erroneous thinking behind many school approaches is that students should spend years being drilled in a set of methods that they can use later" (p. 31), while for professional mathematicians, "[m]athematics is all about illuminating relationships such as those found in shapes and in nature" and constitutes "a powerful way of expressing relationships and ideas in numerical, graphical, symbolic, verbal and pictorial forms" (p. 19). Such disparities could be attributed to the different ways epistemological beliefs and practices developed by these two communities of practitioners (professional mathematicians and school teachers), as well as to the curricular emphases on procedural or conceptual knowledge, as set by policy makers (Garegae, 2016).

The literature on mathematics teachers' epistemological beliefs is quite extensive and, even though there is no standard taxonomy (Mura, 1993), a variety of empirically grounded frameworks are proposed by colleagues. The first and most utilised frameworks are those of Ernest (1989, 1991) and Lerman (1990). Ernest describes three types of epistemological beliefs, namely the Platonist view, the instrumentalist view, and the problem solving view. From the Platonist view, mathematics is seen as a static but unified body of knowledge, whose structure and interconnections between various topics are fundamentally important. The instrumentalist view holds that mathematics is a useful and essentially unrelated collection of facts, rules and skills. Finally, the problem solving view sees mathematics as a dynamic and creative human invention and a problem-driven field of enquiry. Similarly, Lerman (1990) describes a bipolar framework, with apparent similarities to that of Ernest. On the one hand, there is the fallibilist paradigm, whereby teachers offer learners problem solving opportunities, through which the processes of mathematics might be developed. In this paradigm, which is related to Ernest's problem solving view, the social construction of mathematical knowledge is acknowledged. On the other hand, Lerman talks about the absolutist paradigm. Similar to Ernest's Platonist view, this paradigm sees mathematics as "an immutable body of knowledge, where creativity occurs only at the