



The discursive construction of mathematics teacher self-efficacy

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Accepted: 15 September 2020 / Published online: 13 October 2020
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Abstract

Previous studies of in-service teachers indicate strong links between teacher self-efficacy and factors such as instructional quality and pupils' achievement. Yet, much of this research approaches self-efficacy from the perspective of teaching, and not of subject knowledge. Furthermore, the majority of such studies employ quantitative measures of self-efficacy. Drawing on semi-structured interviews with 22 experienced elementary teachers, this paper takes a different approach. The interviews, broadly focused on teachers' mathematics-related beliefs, brought to the surface four themes around which teachers construct their mathematics teacher self-efficacy. These concern participants' perspectives on their mathematics-related past experiences, mathematical competence, ability to realise their didactical visions and resilience in the face of challenging mathematical situations. These themes, which are discussed in relation to existing literature, not only confirm the complexity of self-efficacy but also highlight the need for greater attention to its conceptualisation and measurement.

Keywords Mathematics · Mathematics teaching · Qualitative approach · Teachers' self-efficacy

Teacher self-efficacy, a topic of extensive research both within and outside mathematics education, is often defined as teachers' judgements about their own capabilities to influence pupils' learning in positive ways (Carney, Brendefur, Thiede, Hughes, & Sutton, 2016; Pajares, 1996; Tschannen-Moran & Woolfolk Hoy, 2001). Typically drawing on Bandura's (1977, 1997) *social cognitive theory*, self-efficacy is conceived as a future-oriented judgement concerned more with people's perceptions of their own competence than with actual

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competence. Nonetheless, “these estimations may have consequences for the course of action” individuals “choose to pursue and the effort they exert in those pursuits” (Woolfolk Hoy & Burke-Spero, 2005, p. 344). Over the years, studies have established positive links between teacher self-efficacy and, inter alia, pupil achievement (Bruce & Ross, 2008); instructional quality (Depaep & König, 2018); teachers’ management of educational reform (Gabriele & Joram, 2007) and teacher retention (Day & Gu, 2014). Alternatively, negative links have been highlighted between self-efficacy and teacher anxiety (Gresham, 2008) and burnout (Brouwers & Tomic, 2000).

In mathematics education, studies of teacher self-efficacy have been predominantly quantitative, typically drawing on survey techniques and pre-determined scales. Many of them (i.e., Althaus, 2015; Bates, Latham, & Kim, 2011; Chang, 2015; Gresham, 2008; Hudson, Kloosterman, & Galindo, 2012; Swars, Daane, & Giesen, 2006) have employed variants of the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) (Enochs, Smith, & Huinker, 2000), which combines two subscales focused on *personal mathematics teaching efficacy* and *mathematics teaching outcome expectancy*. In cases where mixed methods have been used, studies included a major survey component, followed by a small number of qualitative interviews to confirm or illuminate the statistical findings (i.e., Charalambous, Philippou, & Kyriakides, 2008; Gresham, 2008). This paper is based on the premise that the uncritical use of scales originally developed for a specific cultural/educational context may create severe validity problems (Andrews & Diego-Mantecón, 2015), as well as not allowing culture- and context-specific issues—impossible to capture with surveys—to surface (Xenofontos, 2018).

In light of such matters, and acknowledging that qualitative approaches to the study of teachers’ beliefs are not problem-free (Speer, 2005), this paper is in line with the voices of colleagues within (i.e., Philippou & Pantziara, 2015) and outside mathematics education (i.e., Wyatt, 2015) who advocate for the need of more studies that approach teacher self-efficacy in qualitative, exploratory ways. Based on an explicitly and exclusively qualitative design, this study aims to provide answers to the following question:

What issues, typically not captured by quantitative studies, emerge from a qualitative exploration of mathematics teacher self-efficacy?

In the next section, the literature on mathematics teacher self-efficacy is explored. Subsequently, we present our methodology, followed by our main findings. In closing, we discuss how this study provides new insights into the complexities of defining and examining teacher self-efficacy.

1 Theoretical considerations

1.1 What is self-efficacy and where does it come from?

Introduced by Bandura (1977, 1997), the concept of self-efficacy is concerned with beliefs people hold for themselves regarding their capabilities to succeed in specific situations, accomplish given tasks or produce given attainments. It is a multidimensional construct and a core mechanism of human agency (Bandura, 2005). Being a future-oriented judgement, “[s]elf-efficacy is not concerned with what someone believes they *will* do, but about what someone believes they *can* do” (Maddux & Kleiman, 2016, p. 89) in specific conditions. In general, self-efficacy is a consequence of learning, in which social relationships play an important role (Brouwers & Tomic, 2000) and, according to Bandura (1977, 1997), typically

stems from four sources: mastery experiences, vicarious experiences, verbal persuasion and emotional arousal. Mastery experiences (or performance accomplishments) serve as direct indicators of capabilities. They draw on repeated successes and enhance an individual's self-confidence and behaviour towards future challenges. According to Ross and Bruce (2007), mastery experiences are the most susceptible to teacher professional development activity. Vicarious experiences, which draw on models of behaviour derived from the observation of others, serve to persuade individuals that they can also achieve what they have observed. Verbal persuasion, important in a didactical context, encourages individuals to believe in their own capabilities. Emotional arousal, which is an explicitly psychological construct, influences self-efficacy judgements regarding specific tasks. For example, anxiety may lead to negative judgements of one's ability to complete a task. Furthermore, in environments that nurture positive emotional outcomes, such as stress reduction, individuals may freely focus and concentrate on completing their tasks effectively. Maddux (1995) adds a fifth source of self-efficacy, which he calls *imaginal experiences*, the ability of an individual to visualize oneself behaving effectively or successfully.

1.2 Teacher self-efficacy in mathematics education research

A closer look at the relevant mathematics education literature indicates particular patterns in how teacher self-efficacy has been conceptualised and operationalized. Approaches appear to differ, depending on whether the focus is on pre-service or in-service teachers.

From the perspective of pre-service teachers, colleagues typically approach self-efficacy as a two-dimensional construct, comprising both *mathematics* self-efficacy (one's perceptions on own subject knowledge) and *mathematics teaching* self-efficacy (one's perceptions on own abilities to teach mathematics in meaningful and supportive ways) (i.e., Bates et al., 2011; Briley, 2012). Furthermore, self-efficacy is often examined in relation to *actual* mathematics subject knowledge (Akay & Boz, 2010; Carney et al., 2016). As typically concluded, the two dimensions are interrelated, and both impact on prospective teachers' mathematical competence, knowledge of mathematical concepts and fluency of procedures (Bates et al., 2011; Briley, 2012; Li & Kulm, 2008). Indeed, these conclusions echo Beswick, Callingham, and Watson (2012), who argue that concepts like teacher self-efficacy and confidence are not at all unrelated to content knowledge; in fact, they refer to the same underlying constructs and constitute various facets of teacher knowledge.

From the perspective of in-service teachers, the limited number of studies undertaken has focused on mathematics *teaching* efficacy, or participants' perceived efficacy of their abilities to teach mathematics effectively and manage the classroom (see, for example, Charalambous & Philippou, 2010; Wilhelm & Berebitsky, 2019). With occasional exceptions (i.e., Andrews & Xenofontos, 2015; Beswick et al., 2012), colleagues have overlooked mathematics self-efficacy (or, in other words, teachers' judgements about their own subject-matter competence). This fact alludes to a hidden (yet erroneous) assumption that in-service teachers have a high sense of mathematics self-efficacy. Such conceptual and operational decisions may stem from a misunderstanding and erroneous interchangeable use of the notions of "mathematics *teacher* self-efficacy" and "mathematics *teaching* self-efficacy". The former is more generic, concerned with beliefs held by teachers and includes the latter, along with teachers' beliefs about

Mathematics teacher self-efficacy	
<p><i>Mathematics self-efficacy</i></p> <ul style="list-style-type: none"> • Self-efficacy about subject knowledge • Teachers' perceptions on their own mathematical competence 	<p><i>Mathematics teaching self-efficacy</i></p> <ul style="list-style-type: none"> • Self-efficacy about pedagogical content knowledge • Teachers' perceptions on their own abilities and skills to teach mathematics in effective ways and facilitate pupils' learning

Fig. 1 Our working conceptualisation of mathematics teachers' self-efficacy

their own mathematical competence. Figure 1 summarises our working conceptualisation of mathematics teacher self-efficacy.

Our assumption, drawing on earlier work with mathematics pre-service teachers (Bates et al., 2011; Briley, 2012; Kaasila, Hannula, Laine, & Pehkonen, 2008), is that in-service teachers with more positive mathematics self-efficacy will have more positive mathematics teaching self-efficacy. Yet, the lack of studies addressing in-service teachers renders the work presented here both necessary and relevant to mathematics education research. Moreover, as with studies of psychological constructs generally, many existing self-efficacy studies invoke pre-determined categorisations intended for survey purposes in particular cultural contexts, with the consequence that sub-categorisations or specific cultural perspectives may go unnoticed. Studies that allow beliefs to be examined without pre-determined categorisation are required.

2 The study

This paper is framed as an instrumental exploratory collective case study. It is instrumental because our aim is to advance understanding of the issue under scrutiny (Garner & Kaplan, 2019), exploratory because we aim to develop hypotheses for further inquiry (Guzey & Ring-Whalen, 2018) and collective because it engages with the professional realities of a cohort of teachers from the same educational/cultural context (Bray, 2011; Xenofontos, 2019). According to Flyvbjerg (2006), “a discipline without a large number of thoroughly executed case studies is a discipline without systematic production of exemplars”, and “a discipline without exemplars is an ineffective one. In social science, a greater number of good case studies could help remedy this situation” (p. 242). Here, we draw on data from semi-structured interviews, conducted in the Republic of Cyprus (hereafter Cyprus), focused on the professional realities of in-service teachers. In the following pages, we use the terms *elementary school* (ages 6–11), *gymnasium* (lower secondary, ages 12–14) and *lyceum* (upper secondary, ages 15–17), which refer to the structure of the Cypriot educational system.

2.1 Participants

Following an open call and a word-of-mouth recruitment approach, 22 in-service elementary teachers (18 identifying as women and 4 as men) volunteered to participate. All of them had received their initial teacher education at the state-funded programmes of Cyprus or Greece, to which admission was highly competitive. At the time this study was conducted, most elementary teachers working in public schools had studied in those programmes in the two countries. Therefore, our sample here is not atypical of the wider population of teachers. This ensured that participants belonged to the generation of Greek-Cypriot teachers considered among the “best” lyceum achievers. This has changed in recent years with the establishment of private universities in 2007, which admit high school graduates to their initial teacher education programmes with less strict entry criteria. All participants can be construed as typical (Xenofontos, 2018), in the sense that the educational system of Cyprus is highly centralized (Andrews & Xenofontos, 2015; Charalambous, Delaney, Yu-Hsu, & Mesa, 2010), with all teachers in public schools being employed and evaluated by the education ministry against specific criteria (Zembylas & Papanastasiou, 2004). Furthermore, the vast majority of teachers teach in similar ways, following the same instructional materials prepared by the ministry (Xenofontos, 2014).

Of the 22 participants, 12 had studied advanced mathematics (i.e., differential and integral calculus, Euclidean and analytic geometry) at lyceum and, subsequently, taken a university entrance examination in mathematics. However, an advanced mathematics background was not compulsory for university admittance, and the remaining ten participants, having studied core mathematics at lyceum, secured their place at the state-funded programmes without additional mathematics qualifications. These ten participants had been considered high achievers in other school subjects, such as history, Ancient Greek and English. Overall, participants’ teaching experiences ranged from 8 to 27 years. Table 1 presents demographic characteristics of the participants.

Table 1 Demographic characteristics of the study participants

Pseudonym	Gender	Years of teaching experience	Advanced mathematics in high school
Anna	Female	10	No
Antonis	Male	24	Yes
Athina	Female	8	Yes
Despina	Female	14	No
Electra	Female	12	Yes
Elena	Female	8	Yes
Evangelia	Female	16	Yes
Flora	Female	9	No
Georgia	Female	23	Yes
Julia	Female	14	No
Katerina	Female	23	Yes
Lamprini	Female	14	Yes
Loukia	Female	11	No
Maria	Female	16	Yes
Marilena	Female	18	No
Nikolas	Male	12	Yes
Pavlos	Male	10	Yes
Savina	Female	15	No
Stella	Female	27	No
Tasoula	Female	16	No
Vasia	Female	22	No
Yiannis	Male	15	Yes

2.2 Data collection, analysis and trustworthiness

The semi-structured interview schedule focused on three main areas: (a) mathematics epistemological beliefs (Xenofontos, 2018), (b) beliefs about school mathematics (Xenofontos, 2019) and (c) teachers' self-efficacy (presented here). The interviews were conducted by the first author in a mixture of Cypriot Greek (teachers' home language) and Standard Modern Greek (the "official" language, used in formal contexts such as school). They lasted on average for 40–45 min and were held at nonworking times and places determined by the participants. With respect to self-efficacy, teachers were explicitly asked to consider their own mathematical competence and how they viewed themselves as learners, as well as to evaluate their own competence as teachers of mathematics. Sample questions explicitly regarding self-efficacy can be seen in Fig. 2. The whole interview schedule including questions about all the three main areas (epistemological beliefs, beliefs about school mathematics, self-efficacy) is presented in Xenofontos (2018). As the interviews were semi-structured, not all questions were posed in the same way or, acknowledging that a topic may have been covered at other points, included at all. Questions and the format of the interview schedule were prepared to facilitate the flow of the discussion and to ensure that all major topics were covered.

While the analysis was largely based on responses to the questions explicitly addressing self-efficacy, in the interviews, self-efficacy was often intertwined with other topics. As discussed in Xenofontos (2018), a question could have explicitly intended to look at a specific belief area (i.e., epistemological beliefs), but the informant's response could allude to other areas as well (i.e., school mathematics and/or self-efficacy). Therefore, readers should be aware that the analyses presented here drew on the on the entire dataset and not just responses to the questions presented in Fig. 2.

No pre-determined coding scheme was employed, an approach similar to that of the grounded theorists (Strauss & Corbin, 1998), whereby a randomly chosen transcript was read, re-read and

<p><i>Sample questions about mathematics self-efficacy:</i></p> <ul style="list-style-type: none"> • How do you see yourself as a mathematics learner? Can you give some examples from your experiences? • How do you feel when you have to solve nonroutine mathematical problems? How competent would you say you are? • How do you manage difficulties you may encounter during nonroutine problem solving?
<p><i>Sample questions about mathematics teaching self-efficacy:</i></p> <ul style="list-style-type: none"> • How comfortable do you feel teaching mathematics? • How competent do you feel in helping children learn mathematics? • What are your strong and weak points as a mathematics teacher?

Fig. 2 Sample questions from the semi-structured interview protocol

Moving from codes to categories, and from categories to themes



<i>Codes</i>	<i>Categories (Sub-themes)</i>	<i>Theme</i>
<ul style="list-style-type: none"> • Negative experiences with transitions from one school level to another • Argument with mathematics teacher in high school • Mother unable to support with homework • Challenges learning mathematics at school • University professor created fear of mathematics • Did not enjoy mathematics modules at university 	<p>Negative experiences (schooling and undergraduate studies)</p>	<p>Perspectives on mathematics-related past experiences</p>
<ul style="list-style-type: none"> • Very good mathematics pupil in school – good grades 	<p>Positive experiences (schooling and undergraduate studies)</p>	

Fig. 3 An example of theme, categories and codes

<ul style="list-style-type: none"> • Mathematical Olympiad contestant • Enjoyed studying mathematics during undergraduate studies • Post-graduate studies in mathematics education 		
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Fig. 3 (continued)

codes identified. The codes derived from the first transcript were applied to a second transcript, where appropriate, and refined. Where new codes emerged, the first transcript was re-read to see if in retrospect they applied to it also. This process continued until the coding of the last transcript, and revealed categories, which were later clustered under four themes (discussed in the next section). Figure 3 demonstrates an example of how different codes were clustered in broader categories, and how these categories composed a more general theme (that is, *perspectives on mathematics-related past experiences*); in similar ways, grounded theorists discuss moving from open to axial coding (Scott & Medaugh, 2017; Strauss & Corbin, 1998). Similar figures about the other three themes can be found in the Appendix of this paper. Importantly, warranting our sample size, research has found that with studies involving a group of relatively homogeneous individuals, between twelve (Guest, Bunce, & Johnson, 2006) and twenty interviews (Sayers, Marschall, Petersson, & Andrews, 2019) should ensure thematic saturation.

Qualitative research creates a translation dilemma when the languages of the data and of their written presentations are different (Temple & Young, 2004). Here, in order to remain as true to informants' intentions as possible, the analyses were conducted on the original Greek data by the first author (Xenofontos), whose first language is Greek. Subsequently, he translated the codes and sample quotes into English for sharing with the second author (Andrews), who is a native speaker of English. Further, Xenofontos shared three randomly chosen coded transcripts with a Greek-speaking colleague from Cyprus, to ensure not only the veracity of the coding but also that all main themes had been captured by the analysis. This process led to some amendments to the coding scheme. Finally, the quotes chosen for this paper were translated from Greek to English by Xenofontos. The accuracy of the translation was checked by an independent writer and text editor who is bilingual (English as first language, Greek as second).

Unlike quantitative research, with its expectations of reliability and validity, naturalistic research necessarily has a high degree of subjectivity (Creswell, 2003; Guba, 1981). In such circumstances, it is incumbent on researchers to take measures to increase the degree of trustworthiness of their work (Guba, 1981). Peer scrutiny of the study was achieved through

“critical friends”, academics working in various areas of educational research from both Cyprus and the UK, providing both insider and outsider perspectives during both the analysis and the writing up processes (Baskerville & Goldblatt, 2009). Finally, in accordance with the aims of comparative research (Andrews, 2009), we hope that our participants and other teachers will “recognise” themselves in the descriptions below. Thus, while we do not claim that the results of this study are objective (in the sense that all researchers analysing the same dataset would have reached the same results and conclusions), a number of measures described above were taken for the demonstration of appropriate levels of trustworthiness.

3 Findings

The analyses described above yielded four themes, which we construe as related to teachers’ self-efficacy. These concern, respectively, the impact of the participants’ mathematics-related past experiences, confidence in one’s mathematical competence, the participants’ beliefs in their ability to realise their didactical vision for the mathematics classroom and their resilience in the face of challenging mathematical situations. In the following, we describe each theme in turn.

3.1 Perspectives on mathematics-related past experience

All 22 participants shared incidents from their experiences as pupils and university students to underpin individual narratives concerning the emergence of their mathematical self-worth. We see these narratives as falling into two broad but clearly polarised groups, one positive and the other negative, distinguished almost exclusively by whether or not colleagues had taken advanced mathematics in lyceum.

The positive comments of the eleven teachers of the first group shared a sense of pride hidden behind emotional neutrality, which seemed self-centred and largely devoid of any reference to other people. Their focus was typically on their own achievements and how comfortable they felt with mathematics. For example, Antonis asserted “I believe my mathematics competence is quite good because of the high level of mathematics I studied at lyceum and the fact that I was very good at it”. In similar vein, Evangelia spoke of her participation in mathematical competitions and later studies in mathematics education:

I would always take part in mathematical Olympiads. Ok, I never received the golden medal, but I would always get at least an honourable mention. (...) Because of my special interest in mathematics as a discipline, I continued my postgraduate studies and received a master’s degree in mathematics education.

By way of contrast, the eleven teachers in the second cluster frequently spoke of their negative experiences in emotionally charged ways and with reference to others whom they held responsible for their low mathematics-related self-esteem. Despina, for example, spoke about the various transitions from one school level to another, none of which was easy for her:

What was a real shock for me was the transition from elementary school to gymnasium. Both the content and approach of the teachers were different, and that made me feel intimidated by mathematics. It took me time to pull myself together. But then, there was another transition, from gymnasium to lyceum. Another huge gap. And, as if all those

changes were not enough, university mathematics and its emphasis on mathematics education was a totally different experience. I'm still a bit intimidated by mathematics, to be honest.

Pavlos was the only teacher who had taken advanced mathematics in lyceum who spoke negatively. His initial experience of school was positive, not least because he excelled on procedural tasks, but things changed when he transferred to gymnasium, where its higher expectations of mathematical abstraction forced him to rely on his mathematically unqualified mother for help, and again when he went to university:

In elementary school, I was fast and accurate with procedural tasks. However, I wasn't that good with nonroutine problems and would always ask my mom for help, a simple housewife with no particular knowledge in mathematics. She couldn't always help me with homework, though, so many times I felt lost. In gymnasium, I was consistently good with other subjects; in fact, I had straight A's, but not in mathematics, no! In maths, it was always a B or a C. In lyceum, my performance gap between mathematics and other subjects got even bigger. I had so many negative experiences that they made me feel I wasn't good at it. At university, we had this very strict professor who made mathematics look like a nightmare.

That being said, not all negative experiences were related to mathematics specifically. Tasoula, for example, described a traumatic experience from lower secondary education, which was related more to her mathematics teacher than the subject itself:

I had a traumatic experience when I was in gymnasium. I had an argument with my mathematics teacher that had nothing to do with mathematics; it was related to how I stood up against him and what I thought to be his unfair behaviour towards a fellow pupil. Yet, at the age of 13, a weird aversion of mathematics started, which I carried to lyceum and later to university.

In summary, with respect to the professional impact of mathematics-related prior experiences, the teachers in this study seemed to have either strongly positive or strongly negative prior experiences with mathematics. Either way, as we discuss later, the different forms of experience-induced mathematical self-worth discussed above have an inevitable and differential impact on teachers' professional self-efficacy.

3.2 Perspectives on mathematical competence

A second theme, identified in all 22 interviews, concerned participants' perspectives on their personal mathematical competence. As with the previous theme, and clearly not unrelated to it, teachers' responses fell into two clusters, distinguished solely by whether or not a teacher had taken advanced mathematics at lyceum.

All twelve participants who had taken advanced mathematics in lyceum felt they were mathematically competent. For some, this sense of competence was undiminished by many years teaching elementary-aged pupils. For example, Evangelia spoke of how comfortable she felt helping her 15-year-old son, who, at the time of this study, was a student in the first year of lyceum:

My son is 15 now, first year of lyceum. He's good in mathematics, but sometimes, when he's stuck with homework, he comes to me for help. All I can say is I'm really pleased

and proud of my competence in lyceum mathematics, especially after all those years of being an elementary teacher. To me, it's like bicycle; once you learn how to ride, you never forget.

In a similar vein, Yiannis, having mentioned that his knowledge of advanced mathematical concepts might be "rusty", spoke of how his experience with advanced mathematics in lyceum had helped him develop transferable skills which can be applied in solving challenging non-routine problems:

In lyceum we were taught topics like calculus, advanced algebra, and analytic geometry. Back then they were a piece of cake. Of course, after all these years of working as an elementary teacher, my knowledge of those topics has definitely become rusty. But it's all about transferable skills. I do believe that I have the skills and competence to adapt my knowledge in order to solve nonroutine problems.

Eleven out of these twelve teachers spoke also of their preference for teaching upper elementary pupils (grades 4–6, age 9–11). Overall, they claimed that lower elementary school grades lacked challenge, while at the same time, they saw the mathematics of the upper classes as more appropriately challenging. Such views, representative of the comments of others, were exemplified by Electra:

Lower grades are basic. Every teacher can teach 2 plus 1 in the first grade. There is no challenge in this. While in upper elementary, things become challenging. You prepare pupils for gymnasium. They need to learn how to think in a more abstract way. This is where I belong. I love mathematics and I feel I need to transmit this enthusiasm and abstract way of thinking to my pupils. (...) Not all teachers can teach grade 6. Those who are less mathematically competent should teach the lower classes.

Of all the members of this group, Yiannis was the only teacher who expressed confidence in his ability to teach mathematics to all grades, claiming that each grade is challenging in its own right, and that the joy of teaching lies with helping children grasp mathematical ideas at any level:

Mathematics is not disconnected. You have the same, or similar, concepts, and the older you get, the more deeply you explore them. Of course, the joy of teaching upper elementary mathematics is unique because pupils must solve more complex, nonroutine problems, which I particularly enjoy solving and using in my teaching. Yet, in younger grades, you help children discover, and that joy is unique, too. Basically, in every grade you help children discover something new to them. When you know how to help them discover new knowledge and you see them enjoy this, you receive a great pleasure as a teacher.

By way of contrast, teachers who had not taken advanced mathematics at lyceum typically presented themselves as lacking mathematical competence. For example, in comments typical of others, Loukia said that "[m]athematics has never been my cup of tea. There are many mathematical concepts I don't really understand". In similar vein, Anna, who distinguished between elementary school mathematics and what she called "more advanced concepts and knowledge", claimed that "I feel comfortable with most of the concepts we encounter in elementary school mathematics. But if we're talking about more advanced concepts and knowledge, I can't say the same".

All ten participants in this group, due to their perceived lack of mathematical knowledge, spoke of feeling comfortable only when teaching the lower elementary grades (age 6–8). Flora's response was typical, effectively arguing that her lack of competence would prevent her being able to manage what she perceived would be the challenging questions posed by pupils in the upper elementary grades:

I've been a teacher for nine years now. To be honest, I've only taught grades 1 to 3 so far. I feel comfortable teaching mathematics to children of these ages. (...) Lower elementary mathematics can be more fun and not as advanced as in upper elementary. (...) In grades 4 to 6, children are taught more difficult concepts, like graphs and statistics, probabilities, negative numbers, and they learn how to use algebraic notation. (...) I haven't taught upper elementary mathematics. Well, I chose not to all these years because I don't know how capable I'd be to respond to challenging questions raised by pupils. (...) Children ask unpredictable questions. What if I don't know how to respond?

In summary, with the exception of the outlier Yiannis, whom we discuss no further in this respect, participants' perspectives on their mathematical competence were clearly informed by whether or not they had taken the advanced mathematics course in lyceum. Those that had taken advanced mathematics not only presented themselves as sufficiently competent to teach across all elementary grades but also declared a preference for the mathematical challenge of teaching the older ages. By way of contrast, all those who had not taken advanced mathematics were conscious of a lack of mathematical competence, to the extent that even teaching in the upper elementary grades prompted anxiety. This distinction between the declared competences of the two groups, which we see as indicative of a rather naïve discontinuity between the mathematics of lower and upper elementary schools, may be problematic. On the one hand, those who took the advanced course in lyceum believe that their superior mathematical competence offers professional flexibility: they can choose to teach in the lower years but choose not to; they have the competence and enthusiasm to induct children into, as they see it, a world of mathematical beauty, abstraction and advanced concepts. On the other hand, those who did not take the advanced course appear to be trapped by their self-described lack of competence, fearful of both the unknown and embarrassment. In short, from the perspective of self-efficacy, the extent to which teachers presented themselves as mathematically competent, as we discuss below, has clear implications for how mathematics teacher self-efficacy is conceptualised, particularly from the perspective of self-report measures.

3.3 Perspectives on the realisation of a didactical vision

The third theme, which emerged from 21 of the 22 interviews, addressed teachers' construal of their role as the shaper of children's learning. All 21 claimed that they were efficacious teachers, although, as above, they still tended to fall into two groups, largely based on whether or not they had taken advanced mathematics at lyceum. In the first group, for instance, were all 12 teachers who had previously taken advanced mathematics and, subsequently, expressed confidence in their mathematical competence. These teachers talked about the creation of challenging classroom environments that promote deep understanding of mathematical concepts. For example, in a comment typical of others, Katerina said,

I want children in my classroom to be challenged. I want them to think. When they give me an answer, I ask them back *why*. At the beginning of each school year, I can see many of them being annoyed by all my *why* questions. Usually, by the end of the year, they realise that they won't get away by simply giving me an answer and not explaining how they got to that. (...) I feel very good at challenging my pupils this way and make them think.

An interesting and largely unexpected outcome of the utterances of 10 of these 12 participants concerned time management and colleagues' inability to stick to their plans. The reasons behind these concerns were eloquently expressed by Maria:

Because I love mathematics so much, sometimes I don't stick to my lesson plan. (...) When I notice children who are more capable, I feel I want to push them even further. As a result, I don't manage to handle time as I would like. This is something I want to improve: How to better manage my planning and teaching.

The second group comprised those teachers who had not taken advanced mathematics in lyceum and who, consequently, expressed low confidence in their own mathematical competence. These teachers spoke of the creation of classroom environments that minimise negative experiences, and in which children feel safe and comfortable with mathematics. In this respect, Savina's comment was typical. She said, "[i]n my class, I help children learn mathematics through innovative approaches. They can even take off their shoes and sit on the floor in my class. It's like a creative chaos; yet everything is under control". In a similar manner, Despina commented on how she had used her prior negative experiences to help her become a highly competent teacher with, in her words, "good teaching skills". For Despina, the links between prior experiences and her current teaching skills appear to have a compensating relationship:

Even though I don't have an advanced mathematical knowledge, I think I have the skills to help elementary pupils learn mathematics. Maybe, I managed to turn this sense of fear of mathematics into good teaching skills. I don't want pupils to share the same intimidation I experienced in school. This is what makes people like me stand out. I would even say that I'm a better teacher of mathematics than my colleagues, who are more mathematically competent.

However, in her and others' utterances, the mechanisms by which colleagues actually helped "elementary pupils learn mathematics" seemed masked by the desire to ensure emotional security.

Finally, and irrespective of their perspectives on the classroom environment, 18 teachers described themselves as open-minded and made explicit distinctions between themselves and their "traditional" colleagues. For example, Savina, a teacher who had not taken advanced mathematics in lyceum, commented that "[m]ost teachers are traditional. They are like horses wearing blinders. They only know one way. I don't see myself as them. I'm not the typical teacher. In my class, I help children learn mathematics through innovative approaches". In a similar vein, Yiannis, who had taken advanced mathematics in lyceum, commented that "I always try to find new ways to help each child, according to their own needs. Unfortunately, most teachers I've worked with is not like this. They are more traditional".

In sum, 21 of the 22 teachers of this study, irrespective of any expressions of mathematical competence, asserted confidence in their ability to fulfil their didactical visions for the mathematics classroom. On the one hand, teachers with strong mathematical backgrounds, positive prior experiences and confidence in their mathematical competence spoke of mathematics classrooms as challenging places where mathematical ideas and procedures should be underpinned by a deep conceptual understanding. On the other hand, teachers who had not taken advanced mathematics in lyceum and who expressed negative prior experiences and low levels of confidence in their competence emphasised the affective domain of mathematics learning. They saw themselves as creators of classroom environments in which emphases on enjoyment and safety prevent negative mathematical experiences; yet, they seem to subordinate mathematical knowledge to emotional security. Importantly, teachers' didactical visions, effectively distinguished by emphases on cognition and affect respectively, have major implications for learning and, as a consequence, the conceptualisation and evaluation of mathematics teacher self-efficacy.

3.4 Perspectives on personal resilience in challenging mathematical situations

The fourth theme, in contrast with the previous three, did not dichotomise teachers. Indeed, 21 of the 22 participants spoke of their resilience in the face of challenging mathematical situations. Specifically, the participants indicated that, when faced with challenging non-routine problems, they would persevere and would not easily give up. Such opinions were expressed regardless of whether they had taken advanced mathematics in lyceum, and subsequently, whether or not they had expressed confidence in their own mathematical competence. For example, Savina, who had not taken advanced mathematics in lyceum and saw herself as lacking mathematical competence, asserted that:

Even though I might not have sufficient knowledge of mathematics, I don't easily give up! I try to stay focused, have breaks if needed, then come back to the problem and persist. If I really can't solve it, I will ask for help. But this is not the first thing I do. First, I try, then I ask others, and only if necessary.

Similarly, Anna, who had also not taken advanced mathematics in lyceum, spoke about how she would try to solve problems herself before turning to her mathematically competent husband:

If I had to solve a problem that required more advanced knowledge, I'd be anxious, but I'd try. I wouldn't give up. Let's say I find a mathematical riddle in a newspaper, or something like Sudoku, then I'll give it a try. But if I get stuck, I'll discuss it with my husband. He's more into mathematics than I am. He's an engineer.

Finally, Pavlos, who had reported negative experiences with both school and university mathematics, spoke of how the difficulties he had faced in the past had helped him develop a strong mathematical resilience:

Yeah, I feel quite confident with my knowledge and skills now. All those negative experiences have toughened me up (laughter). So, in a sense, I'm happy I took advanced

mathematics in lyceum. (...) When I have to solve a difficult problem, I get very stubborn, I keep trying and trying. I wouldn't easily quit.

In summary, with a solitary exception, all the teachers cast themselves as mathematically resilient. For those who had taken advanced mathematics at lyceum, this seemed unsurprising as they had also expressed broad satisfaction with respect to their mathematical competence. However, for those who had not taken advanced mathematics at school and who typically cast themselves as lacking competence, their stated resilience seemed incongruous, particularly when the majority of these teachers spoke of their desire not to be challenged by the mathematics of the upper elementary grades. In short, while resilience may have a role in the professional self-efficacy of teachers of mathematics, its relationship with mathematical competence seems ambivalent and likely to challenge the validity of self-report measures of the construct.

4 Discussion

In this paper, based on the premise that quantitative approaches to the study of mathematics teacher self-efficacy may lack sensitivity to the complex nature of the concept as a facet of teacher knowledge (Beswick et al., 2012), we set out to address the question, *what issues, typically not captured by quantitative studies, emerge from a qualitative exploration of mathematics teachers' self-efficacy?* Our view is that our approach has highlighted several matters of significance to the collective understanding of the field, and it is to this that we now turn.

Our analyses identified four themes related to the particularities of the context of Cyprus. The first three themes resonate closely with those yielded by Swars' (2005) interview study of US pre-service teachers, one of only a few examples of similar methodological approaches to the topic. Our themes concerned participants' perspectives on their mathematics-related prior experiences, mathematical competence and ability to realise their mathematics didactical vision. The fourth theme regarded participants' resilience in the face of challenging mathematical situations. It is a theme that draws extensively on classroom experience and is, we suggest, unlikely to have emerged from Swars' pre-service teacher data. Importantly, in the context of Cyprus, the key issue emerging from these three themes is the manner in which teachers attribute failure or success. In the following, acknowledging the transparency of the relationship of all four themes to mathematics teacher self-efficacy, we focus primarily on this important distinction. Readers are reminded that *all* participants in this study (like most primary teachers in Cyprus) were high achievers in their chosen school subjects at lyceum and could have secured positions in other competitive undergraduate programmes (i.e., medicine, law, economics) if they had wanted. Nevertheless, they had all chosen to study education and become primary teachers, as it used to be a highly respected profession, with immediate employment prospects after graduation and a relatively high salary.

In the context of this study, three of the identified themes polarised participants. On the one hand, we find teachers who had taken advanced mathematics in lyceum, spoke of positive experiences as learners and projected themselves as having high levels of competence preferences for teaching the upper elementary levels and didactical visions

of mathematically challenging classrooms focused on conceptual understanding and tasks of high cognitive demands. The beliefs of these teachers resonate with earlier studies showing that mathematics self-efficacy is positively correlated with mathematics teaching efficacy (Bates et al., 2011; Briley, 2012; Caprara, Barbaranelli, Steca, & Malone, 2006), particularly from the perspective of goal-setting (Ross & Bruce, 2007). Moreover, as evidenced in this study, teachers' positive experiences as learners of mathematics impact positively on their professional efficacy, particularly at times of curricular innovation (Drake, 2006), as do low levels of mathematics anxiety (Swars et al., 2006). In essence, and assuming their beliefs are translated into practice, the beliefs of these self-declared mathematically competent teachers, which reflect a range of personal and professional efficacies, resonate with current expectations of effective mathematics teaching.

By way of contrast, none of the teachers at the opposite pole had taken advanced mathematics at lyceum. Those teachers spoke of negative experiences as learners and projected themselves as having poor mathematical competence, preferences for teaching lower elementary levels, fears of upper elementary mathematics and didactical visions of safe learning environments in which pupils would not feel negatively towards mathematics the same way their teachers did. The beliefs of these teachers, roughly half the interviewed cohort, create a worrying picture. Firstly, the relationship between mathematics self-efficacy and mathematics teaching self-efficacy is strong (Bates et al., 2011; Briley, 2012; Caprara et al., 2006; Chang, 2015), potentially compromising this group's professional efficacy. Indeed, their lack of mathematical competence, implicated in goal setting (Ross & Bruce, 2007), coupled with their explicit desire to avoid teaching older children, suggests they lack the horizon mathematical knowledge, or the "awareness of how mathematical topics are related over the span of mathematics included in the curriculum" (Ball, Thames, & Phelps, 2008, p. 403). Secondly, their negative experiences as learners are not only implicated negatively in their professional efficacy (Drake, 2006) but manifested in utterances indicative of mathematics anxiety, with its own strong negative influence on teacher self-efficacy (Gresham, 2008; Swars et al., 2006). Thirdly, the desire to create safe classroom environments, particularly when viewed against their own low levels of mathematics efficacy, tends to result not only in teachers lowering expectations by subjugating children's learning to their emotional security (Eriksson, Boistrup & Thornberg, 2017) but also promoting didactical activities with no learning outcome other than fun (McNeil & Jarvin, 2007; Moyer, 2001). In sum, their beliefs, which also reflect, albeit negatively, various personal and professional efficacies, appear less likely to support the creation of a new generation of mathematically efficacious learners than, unwittingly, a new but different generation of learners lacking mathematics self-efficacy. By avoiding "traditional" practices, they construct learners whose mathematically impoverished experiences may leave them emotionally secure but cognitively challenged.

Our fourth theme, which did not polarise teachers' responses, concerned the participants' resilience in the face of challenging mathematical situations. For the teachers in the first cluster, this seemed unsurprising. However, for those in the second cluster, this seemed incongruous, and it is on them we focus. It is known that self-efficacy is influenced by events (Holzberger, Philipp, & Kunter, 2013), as

highlighted by all participants' prior learning experiences, and that people with weak self-efficacy tend to give up when faced with difficulties (Bandura, 2005). In light of this, we feel compelled to ask, why are teachers with such low levels of professional self-efficacy declaring resilience? One possible explanation, particularly in light of these teachers' preference for teaching within a limited age range, may lie in the relationship between self-efficacy and context familiarity (Charalambous & Philippou, 2010). That is, within the constraints of lower elementary mathematics, they are able to face difficulties and remain resilient to adversity (Bandura, 2005), which is particularly important in the context of Cyprus, where the development of mathematical resilience has high societal value (Xenofontos, 2014). Moreover, as seems to be the case here, irrespective of how mathematically competent one feels, resilient teachers persist in the face of daily challenges and, as a consequence, are likely to remain in the profession (Day & Gu, 2014).

In summary, despite the variation in their espoused beliefs, all participants were perceived by themselves, the national university exams they took to enter their teacher education programmes and the educational system of Cyprus through inspection and teacher evaluation, as successful. This, it seems to us, creates problems for the conceptualisation and measurement of mathematics teacher self-efficacy. As commented at the beginning of this paper, many studies have used variants of a specific instrument, the MTEBI (Enochs et al., 2000). The MTEBI, despite our identifying both subject-related efficacy beliefs and resilience as indicators of teachers' broader teaching self-efficacy, acknowledges neither. Moreover, the MTEBI lacks reliability and fails to address adequately the self-efficacy beliefs of less confident teachers (Kieftenbeld, Natesan, & Eddy, 2011) and the occasionally bizarre but consistent declarations of resilience.

In closing, we return to our methodological assertion concerning instrumental exploratory collective case studies. The study presented above has advanced understanding of the issue under scrutiny (Garner & Kaplan, 2019), developed hypotheses for further inquiry (Guzey & Ring-Whalen, 2018) and engaged with the professional realities of a cohort of teachers from the same educational/cultural context (Bray, 2011; Xenofontos, 2019). It has provided a thoroughly executed exemplar (Flyvbjerg, 2006) to facilitate both conceptual and methodological developments in the field. Our initial conceptualisation of teacher self-efficacy included two components: mathematics self-efficacy and mathematics teaching self-efficacy, which correspond to subject knowledge and pedagogical content knowledge, respectively. The exploratory approach employed in this paper indicates that, in reality, things are much more complex, as these two components often overlap and intertwine. Nevertheless, acknowledging the cultural location of mathematics-related beliefs (Andrews, 2009; Andrews & Diego-Mantecón, 2015; Xenofontos, 2018), we are aware that the four themes identified above are located in the particularities of the Greek-Cypriot educational system and the specific characteristics of those entering teacher education and the teaching profession. Colleagues working elsewhere could undertake similar qualitative investigations, possibly with the same two self-efficacy components as inputs, to examine the discursive construction of self-efficacy in their particular cultural contexts, instead of assuming specific universal characteristics in the manner of previous quantitative studies.

Appendix


Moving from codes to categories, and from categories to themes



<i>Codes</i>	<i>Categories (Sub-themes)</i>	<i>Theme</i>
<ul style="list-style-type: none"> • Feels confident with mathematics • Sense of pride about their mathematical competence • Advanced lyceum mathematics helped them develop competence • Transferable skills from lyceum mathematics • Prefers teaching upper primary mathematics • Lower primary mathematics lacks challenge 	Self-described as mathematically competent	Perspectives on mathematical competence
<ul style="list-style-type: none"> • Doesn't feel mathematically competent 	Self-described as lacking mathematical competence	

<ul style="list-style-type: none">• Mathematics is not their favourite subject• Doesn't fully understand mathematical concepts• Competent with primary school mathematics only• Lack of advanced mathematical knowledge• Prefers teaching lower primary mathematics		
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Moving from codes to categories, and from categories to themes



<i>Codes</i>	<i>Categories (Sub-themes)</i>	<i>Theme</i>
<ul style="list-style-type: none"> • Children should be mathematically challenged • Feels competent in pushing children to think • Sometimes does not stick to lesson plan 	Competent in creating challenging learning environments	Perspectives on the realisation of a didactical vision
<ul style="list-style-type: none"> • Good teaching skills in making children feel safe with mathematics • Their mathematics classroom is fun • Helps children love mathematics 	Competent in creating safe learning environments	
<ul style="list-style-type: none"> • Other teachers are “traditional” • Distinguishes “progressive” self from other teachers 	Open-minded compared to other colleagues	

Moving from codes to categories, and from categories to themes

<i>Codes</i>	Categories (Sub-themes)	Theme
<ul style="list-style-type: none"> • Never give up! • Enjoys mathematical challenges • Keeps working on a mathematical challenge • Asks for help only after trying hard 	Highly developed sense of resilience	Perspectives on personal resilience in challenging mathematical situations

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