Early Childhood Teachers' Professional Competence in Mathematics

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Chapter 5

A math-avoidant profession?: Review of the current research about early childhood teachers' mathematics anxiety and empirical evidence

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Chapter 5

A math-avoidant profession?

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Lars Jenßen

Introduction

Mathematics is important also from a cultural perspective and the confident handling of mathematical requirements can be understood as a 21st century skill (Goldin, 2014). In our educational and knowledge-based societies, mathematics can therefore also trigger a variety of emotions (ibid.). Early childhood (EC) teachers recognize the importance of mathematics and accordingly express positive attitudes towards mathematics (Benz, 2012; Thiel, 2010). The majority of EC teachers also experience mathematics as emotionally pleasant (Sumpter, 2020). Nevertheless, a significant proportion also reports unpleasant feelings about mathematics (ibid.). It is not surprising that EC teachers regard mathematics as a valuable domain on the one hand and are anxious in situations involving mathematics on the other. According to the control-value theory (Pekrun & Perry, 2014), anxiety can result when people assess a domain as valuable and at the same time assess their own resources to deal with the corresponding requirements as low (e.g. low knowledge in this domain). Indeed, it must be assumed that a significant proportion of EC teachers consider their professional knowledge of mathematics to be low (Blömeke, Jenßen, Grassmann, Dunekacke, & Wedekind, 2017; Noviyanti, 2019). Mathematics anxiety (MA) is one of the most studied unpleasant emotions in mathematics (Dowker, Sarkar, & Looi, 2016) and is also considered relevant for EC teachers. Emotions, understood as affective-motivational dispositions, are a significant facet of teachers' professional competence (Blömeke, Gustafsson, & Shavelson, 2015). It can be assumed that affective-motivational dispositions also show effects on relevant aspects of EC teachers' professional competence (Brown, 2005; Cooke, 2015; Oppermann, Anders, & Hachfeld, 2016). This chapter deals with EC teachers' MA and summarizes the current state of research. An empirical study illustrates whether the profession "EC teacher" can be considered a "math-avoidant" profession.

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Phenomenology of mathematics anxiety

MA can be understood as a multifactorial construct that can manifest itself in four different components: affective, cognitive, physiological and behavioral[1] component (Pekrun, Muis, Frenzel, & Goetz, 2018). It is experienced as unpleasant and activating (Pekrun et al., 2018). The affective component of MA can be described as a primary emotional reaction to mathematical demands resulting in fear (Hembree, 1990). Secondarily, helplessness and anger can be experienced. Some authors conceptualize the experience of shame as another primary emotional response (e.g. Wilson, 2017), even though anxiety and shame are two different emotions (Jenßen, Möller, & Roesken-Winter, 2020). Cognitively, thoughts about one's own failure are reported (Hunt, Clark-Carter, & Sheffield, 2014). The thoughts are directed towards the future or evaluate the current situation as challenging or threatening. Even mental blocks are described by people who are afraid of mathematics. Physiologically, above all, tension is described (Hembree, 1990), whereby stronger symptoms such as sweating, a feeling of pressure on the chest or nausea are also possible. The behavioral component of MA describes the avoidance of mathematics-related requirements (Chang & Beilock, 2016), mathematics-related courses during education (Kelly & Tomhave, 1985) or mathematics-related professions (Chipman, Krantz, & Silver, 1992; Huang, Zhang, & Hudson, 2018). Therefore, MA is also conceptualized as the *avoidance of mathematics*. The core feature of MA is that it leads to low mathematical performance, whereby a medium-strong bidirectional effect can be assumed (Carey, Hill, Devine, & Szücs, 2016; Ma, 1999). Women also report higher levels of MA (Sokolowski, Hawes, & Lyons, 2019). MA can occur as an emotional reaction to a specific situation (state) or on a generalized level (trait), as a common emotional tendency of an individual across different situations (Hannula, 2019). In educational research, MA is conceptualized as an emotional disposition that can range from lower MA via medium MA to higher MA (Ashcraft, 2002). However, in clinical psychology, MA can also be conceptualized as a specific phobia with states of intensively experienced panic when working on mathematical tasks (Hembree, 1990).

Early childhood teachers' mathematics anxiety

MA can be considered a poorly researched construct in EC teachers, although many authors consider it a relevant construct for this population. Assumptions about EC teachers' MA are mainly based on results from studies with primary school or secondary school teachers which may not be transferrable to EC teachers. In the following review of the previous studies, a total of 16 studies were considered that explicitly deal with EC teachers' MA (see Table 5.1). Most of the studies come from the United States or Germany and deal with MA of pre-service EC teachers. In the following, the results of the studies are reported separately for pre-service and in-service EC teachers. It has to be noted that MA might have

Table 5.1 Overview of the included studies

Phase of career	*Participants*	*Country*	*Design*	*Methodological approach*	*Type of assessment for mathematics anxiety*	*Additional variables*	*Authors*
Pre-service	$n = 246$ K-6 teachers	US	Longitudinal (1 semester)	Mixed methods	Standardized questionnaire (MARS), interviews	None	Gresham (2007)
	$n = 156$ K-6 teachers	US	Cross-sectional	Mixed methods	Standardized questionnaire (MARS), interviews	Mathematics teacher efficacy	Gresham (2008)
	$n = 53$ early childhood teachers	Australia	Cross-sectional	Quantitative	Standardized questionnaire (no specific name is given in this paper)	None	Cooke, Cavanagh, Hurst and Sparrow (2011)
	$n = 89$ early childhood teachers	US	Cross-sectional	Qualitative	Interviews	None	Bates, Latham and Kim (2013)
	$n = 30$ early childhood teachers (only female)	US	Longitudinal (1 semester)	Mixed methods	Standardized questionnaires (AMAS)	Beliefs, stereotypes in math	Lake and Kelly (2014)
	$n = 73$ early childhood teachers (results are reported for $n = 223$ pre-service teachers, where $n = 155$ were studying primary education)	Australia	Longitudinal (9 weeks)	Mixed methods	Standardized questionnaires (no specific name is given in this paper)	Attitudes towards mathematics, reasons for feeling anxious in mathematics	Boyd, Foster, Smith and Boyd (2014)

(Continued)

Table 5.1 (Continued)

Phase of career	*Participants*	*Country*	*Design*	*Methodological approach*	*Type of assessment for mathematics anxiety*	*Additional variables*	*Authors*
	$n = 354$ early childhood teachers	Germany	Longitudinal (3 weeks)	Quantitative	Standardized questionnaire (MAS-R)	Mathematical content knowledge	Jenßen, Dunekacke, Eid and Blömeke (2015)
	$n = 12$ Pre-K-4 teachers	US	Cross-sectional	Qualitative	Interviews	Mathematics self-efficacy, mathematics teachers' efficacy	Gresham and Burleigh (2018)
	$n = 225$ early childhood teachers	Norway	Cross-sectional	Quantitative	Standardized questionnaire (MAS-R)	Mathematical knowledge for teaching	Thiel and Jenßen (2018)
	$n = 354$ early childhood teachers	Germany	Cross-sectional	Quantitative	Standardized questionnaire (MAS-R)	Mathematical content knowledge, mathematics pedagogical content knowledge, math-related perception	Jenßen, Thiel, Dunekacke and Blömeke (2019a)
	$n = 392$ early childhood teachers	Norway	Longitudinal (1 academic year)	Quantitative	Standardized questionnaire (MAS-R)	Mathematics enjoyment	Thiel (this book)
Pre-service and in-service	$n = 100$ pre-service early childhood teachers and $n = 50$ in-service early childhood teachers	Turkey	Cross-sectional	Quantitative	Standardized questionnaire (MAS-R)	Beliefs about mathematics	Aslan (2013)

(Continued)

Phase of career	*Participants*	*Country*	*Design*	*Methodological approach*	*Type of assessment for mathematics anxiety*	*Additional variables*	*Authors*
	$n = 10$ K-6 teachers	US	Longitudinal (5 years)	Mixed methods	Standardized questionnaire (MARS), interviews	Mathematics teaching efficacy	Gresham (2018)
	$n = 129$ early childhood teachers	Germany	Longitudinal (4 years)	Quantitative	Standardized questionnaire (MAS-R)	Mathematics content knowledge, mathematics pedagogical content knowledge, mathematics enjoyment	Jenßen, Eid, Szczesny, Eilerts, and Blömeke (2021)
In-service	$n = 20$ early childhood teachers and $n = 400$ children	Turkey	Cross-sectional	Quantitative	Standardized questionnaire (MAS-R)	Beliefs about mathematics, children's mathematics achievement	Aslan, Ogul and Tas (2013)
	$n = 48$ early childhood teachers and $n = 362$ children	Germany	Cross-sectional/ longitudinal	Quantitative	Standardized questionnaire (MAS-R)	Mathematics content knowledge, children's development of mathematical competence	Jenßen, Hosoya, Jegodtka, Eilerts, Eid and Blömeke (2020)

AMAS = Abbreviated Math Anxiety Scale (Hopko et al., 2003), MARS = Mathematics Anxiety Rating Scale (Richardson & Suinn, 1972), MAS-R = Mathematics Anxiety Rating Scale – Revised (Bai et al., 2009).

different meanings for pre-service EC teachers in comparison to in-service EC teachers. Pre-service teachers might be rather conceptualized as learners than as teachers. Consequently, from the perspective of control-value theory (Pekrun & Perry, 2014), MA might be meaningful for pre-service EC teachers with regard to its effects in achievement and learning situations during teacher education. On the other hand, in-service EC teachers are teaching in practice and MA changes its meaning to a teacher emotion that is rather affected by pedagogical factors (e.g. children's achievement behavior, pedagogical goals of the teacher) than by the domain itself. This assumption is covered by the model of teacher emotions developed by Frenzel (2014). One could argue that the difference is based on the differentiation between MA in achievement situations (pre-service) and MA in pedagogical situations (in-service). Nevertheless, a situation in which the EC teacher's teaching behavior is focused may be perceived additionally as an achievement situation with regard to mathematical content by the EC teacher.

Mathematics anxiety of pre-service early childhood teachers

MA in pre-service EC teachers can manifest itself in different situations: in a learning situation in a mathematics class, in taking a formal mathematics test and in anticipating the teaching of mathematics (Cooke, Cavanagh, Hurst, & Sparrow, 2011). The test situation and the teaching situation have the most challenging character (ibid.). Pre-service EC teachers attribute their MA mainly to their own experience in mathematics (Boyd, Foster, Smith, & Boyd, 2014). The teacher educator's teaching style can be seen as an important factor: too fast progress, poor explanations by the teacher or directive teaching styles can be seen as negative. Self-related beliefs such as "Mathematics is an innate ability" can sustain MA (ibid.). In addition, pre-service EC teachers experience a lower self-confidence in their ability to teach mathematics, which is also due to a lack of knowledge of teaching methods and mathematical knowledge (Bates, Latham, & Kim, 2013). A vicious cycle can be assumed, because poor knowledge in mathematics is also a consequence of the MA. Pre-service EC teachers' MA shows, as expected, negative correlations of medium strength with the professional knowledge in mathematics required for later teaching (Thiel & Jenßen, 2018). The effect of MA seems to be stronger than the effect of mathematics self-efficacy (ibid.). Studies that differentiate professional knowledge into mathematical content knowledge (MCK) and mathematics pedagogical content knowledge (MPCK) showed that MA is mainly associated with MCK (Jenßen, Thiel, Dunekacke, & Blömeke, 2019a; Jenßen, Eid, Szczesny, Eilerts, & Blömeke, 2021). This connection is stable at a trait level under natural conditions and is probably formed mainly by the cognitive component of MA (Jenßen, Dunekacke, Eid, & Blömeke, 2015). The negative relation can be assumed for all mathematical content domains relevant for EC education (number and operations; geometry; measurement and quantity; data and chance), whereby it is stronger for "number and operations" than for "data and chance"

(ibid.) For MPCK, the findings are divergent. It can be assumed that MA on MPCK shows only an indirect effect mediated by MCK. This is rather of low-to-medium strength (Jenßen et al., 2019a). The same effect can also be assumed for situation-specific skills such as the professional perception of mathematics-related content in EC educational situations (ibid.). In addition to the cognitive component, MA is also associated with other affective-motivational tendencies, especially mathematics self-efficacy (Gresham & Burleigh, 2018) and mathematics teaching efficacy (Gresham, 2008; Gresham & Burleigh, 2018).

The majority of the studies is concerned with the design of EC teacher education to cope with MA. Lake and Kelly (2014) impressively describe how difficult it is to change MA in a course on early mathematical education (especially didactics). No reduction of MA could be achieved. Boyd et al. (2014) argue that a positive attitude towards mathematics during education can be conveyed if student teachers are made aware of their responsibility for teaching. A key factor appears to be the promotion of conceptual knowledge rather than procedural knowledge and the use of materials to significantly reduce MA (Gresham, 2007). Furthermore, reform-based constructivist methods, peer teaching opportunities and field experience are recommended to address the MA of pre-service EC teachers (Gresham & Burleigh, 2018). Thiel and Jenßen (2018) have found that older student teachers experience less MA. They attributed this result to the fact that these student teachers were able to gain practical experience in EC institutions even before the training. In his current study, Thiel (this book) shows once again that the reflection of practical experience based on professional knowledge in mathematics can help to reduce MA. Practical experience during training thus seems to be a powerful factor in the reduction of MA, but it should be professionally supported within the training.

Mathematics anxiety of in-service early childhood teachers

Surprisingly, a cross-sectional design showed that in-service EC teachers had higher levels of MA than pre-service EC teachers (Aslan, 2013). In fact, however, longitudinal analyses show that MA decreases significantly from training to practice (Gresham, 2018; Jenßen et al., 2021). Nevertheless, the study by Gresham (2018) also shows that MA can still remain high. It has to be noted that explicitly high-math-anxious teachers were interviewed in this study. According to Jenßen et al. (2021), the reduction of MA could be mainly due to the fact that MA probably changes its meaning from anxiety in learning and test situations to anxiety in teaching situations, whereby the construct moves somewhat away from the learning object. This assumption is in line with models of teacher emotions (Frenzel, 2014). An effect in the study of Jenßen et al. (2021) supports this assumption: Existing negative relations to MCK and MPCK during EC teacher education no longer existed in practice. Overall, no clear result is yet evident. Another study with in-service EC teachers in Germany still showed a medium negative association with MCK (Jenßen et al., 2020).

Although it is theoretically assumed (and empirically evident for primary and secondary school teachers, e.g. Hadley and Dorward, 2011; Ramirez, Hooper, Kersting, Ferguson, & Yeager, 2018) that a teacher's emotion can affect the students' achievement (Frenzel, 2014), no study has been able to validate a link between in-service EC teachers' MA and the mathematical competences of children so far (Aslan, Ogul, & Tas, 2013; Jenßen et al., 2020). The study of Aslan et al. (2013) revealed no significant effects of EC teachers' MA on children's mathematical competence. Jenßen et al. (2020) also could not prove a significant effect of EC teachers' MA on children's competence development in mathematics even under control of EC teachers' MCK. However, the authors point out methodological difficulties in adequately modeling the conditions of EC institutions (e.g. several EC teachers are responsible for one child).

Limitations of the existing studies

The studies included in the review vary in sample size and composition. In some studies, only women were examined. The educational level also differs between post-secondary level (vocational schools) and tertiary level (university) due to the international variations in the types of education (Gasteiger, Brunner, & Chen, 2020). In some studies, EC teachers and elementary teachers were examined together, as they are trained together in some countries or the teaching qualification can extend beyond kindergarten to primary school (see Gresham & Burleigh, 2018). This limits the validity of the results of international comparisons. Self-reporting assessments were used in all studies (interviews and questionnaires). Observation methods or physiological methods as objective assessments have not been used so far. The majority of studies focus only on pre-service EC teachers. Only very few studies follow an intervention design. Only in very few studies, it was controlled for cognitive variables (e.g. professional knowledge in mathematics).

Desiderata

The reported studies show that MA can be seen as a relevant variable when examining pre-service as well as in-service teachers' professional competence. Studies showed that MA shows effects on the career choice of math-related professions (e.g. Chipman et al., 1992; Huang et al., 2018), in the sense, that individuals with higher MA tended to avoid these professions. Career choice is a very complex process that is primarily conceptualized as a multifactorial structure of cognitive and social but also of emotional factors (Watt & Richardson, 2007; Wigfield & Eccles, 2000). For prospective teachers, intrinsic and extrinsic motivations are often examined (Watt et al., 2012), and the pedagogical facet of teachers' intrinsic motivation is usually emphasized (Laschke & Blömeke, 2016). When pedagogical professionals are trained as generalists, as this is often the case for primary school teachers and EC teachers, it must be assumed that interest in mathematics is not the primary consideration when choosing this profession.

Additionally, the profession "EC teacher" might be rather associated with pedagogical interests, especially in countries, such as Germany, which show a more social-pedagogical orientation than a school-orientated one. Consequently, one could argue that the profession "EC teacher" is not subjectively associated with mathematics. This in turn would lead to the effect that individuals with higher MA tend to choose this profession for their prospective work. Until now, no study investigated whether MA is a factor that affects the choice of becoming an EC teacher. Or in other words, whether the profession "EC teacher" can be seen as "a math-avoidant profession".

The current study

Background and research question

The current study is part of the *KomMa* project.[2] The main aim of the project was to assess pre-service EC teachers' professional competence in the field of mathematics during their training from beginning to end. In Germany, EC teachers are usually trained at vocational schools as "general educators" for ages 0–18 years (e.g. working later on in the youth welfare system, children's home or preschool) (Gasteiger et al., 2020). The training covers courses in general pedagogy but also includes specific courses in EC education. The number of courses taught specifically related to mathematics within the early years can be seen as very diverse in the vocational schools across all federal states in Germany (Blömeke et al., 2017). Pre-service general educators have to choose at the end of their training, whether they want to work as an EC teacher or whether they want to work in another profession as an educator outside of formal educational institutions (e.g. youth welfare system). In comparison to other countries, they are not allowed to choose the profession "primary school teacher". Consequently, one could say that becoming an EC teacher is the most thinkable formal profession with relations to mathematics for the pre-service educators.

The research question of the present study is whether MA shows effects on pre-service educators' prospective choice during their last year of training to work as an EC teacher. In light of empirical findings and theoretical assumptions, a positive effect of MA on the choice to work as an EC teacher is hypothesized.

Participants, measures and data analysis

To answer the research question, $n = 774$ pre-service educators at the end of their training were asked whether they want to work prospectively as a teacher in EC institutions. Answers could range from "1 = in no case" to "4 = in any case" and represented the variable CHOICE. The present sample covers only those participants of the full *KomMa* sample who were at the end of their training and who were trained at vocational schools (cf. Blömeke et al., 2017). Participants' average age was $M = 23.7$ years (SD = 5.2) and the majority was female (83%).

MA was assessed as an emotional disposition by a standardized questionnaire which was used in PISA 2003 to assess students' MA (Lee, 2009). The adapted questionnaire contains four statements (see Appendix A) which have to be evaluated on a four-point Likert scale ranging from "1 = totally disagree" to "4 = totally agree". Higher values represent a higher level of MA. The questionnaire covers affective (feelings of helplessness), cognitive (worrying) and physiological (nervousness) components of MA. The adapted version shows satisfactory reliability within the current application (Cronbach's alpha = .89) and can be seen as internationally valid (Lee, 2009).

To control for cognitive variables such as professional knowledge, pre-service EC teachers' MCK and MPCK were included in the model to be tested. Educators' MCK and MPCK were tested with the KomMa-MCK-Test and the KomMa-MPCK-Test (Blömeke et al., 2017). Both tests assess specific professional knowledge of EC teachers in Germany, which is gained during their training (Blömeke et al., 2017). The KomMa-MCK-Test contains 24 items covering all relevant mathematical domains for mathematics in the early years (numbers and operations, geometry, quantity and relation, data and chance) and can be assumed as reliable (Rel. = .88). The KomMa-MPCK-Test contains 28 items covering EC teachers' professional knowledge in the domains "diagnosing children's mathematical development" and "designing informal learning environments". The reliability of the test is good (Rel. = .87).

Data were analyzed by applying structural equation modeling. MA was represented by four indicators while MCK and MPCK were included as the latent ability scores, which were created by applying 2PL models for the whole *KomMa* sample (Blömeke et al., 2017). The variable CHOICE was also included as a categorical manifest variable. Correlations between MA, MCK and MPCK were tested as well as regression coefficients from CHOICE on MA, MCK and MPCK.

Results

The raw scores of each variable are reported in Table 5.2. The MA score (sum over all four items) had a potential range of 4–16, so the theoretically expected mean is 10. The empirical mean seems to be comparably high to the theoretically expected mean. The KomMa-Tests were developed such that scores represent

Table 5.2 Descriptive results

	Mathematics anxiety	*Mathematics content knowledge*	*Mathematics pedagogical content knowledge*	*Prospective choice of ECEC*
Mean (standard deviation)	10.28 (3.31)	48.40 (9.64)	49.84 (9.25)	2.72 (.86)
Empirical range (minimum–maximum)	4–16	20–79	15–73	1–4

a normal distribution, so the standardized mean is $M = 50$ and the standard deviation is SD = 10 for the full sample of the *KomMa* project. Consequently, the scores of MCK and MPCK in this sub-sample were closely related to these values. The manifest variable CHOICE had a potential range from min = 1 to max = 4. Higher values indicated a choice in favor of EC education. The mean of CHOICE in the present study was $M = 2.72$. The majority of pre-service educators (59%) answered they can imagine themselves working in the context of EC education (answer at least 3).

The manifest variances and the correlations between all included variables of the structural equation model are presented in Table 5.3. All variances were significant ($p < .001$). MA was negatively associated with MCK and MPCK. The correlation between MA and MCK was stronger than the correlation between MA and MPCK. MCK and MPCK were positively related to each other. The size of the correlation was moderate. MA as well as MCK were related to the choice to work in EC institutions, but MA was positively related and MCK was negatively related. Both sizes of these relations were small. No significant correlation between MPCK CHOICE was found.

To test the hypothesis, the theoretical assumptions were modeled by applying structural equation modeling. MA as a latent trait was measured by four indicators and all factor loadings were significant ($p < .001$) and substantial. Results are presented in Figure 5.1. Curved lines represent correlations and straight lines represent regressive relationships between two variables. The model fitted the data well ($\chi^2(11) = 11.92$, $p = .3694$, RMSEA = .01 [0.00; 0.04], SRMR = .01, CFI = 1.00). MA showed a significant positive effect on CHOICE ($p < .001$). This effect was small. The higher the level of MA, the lower is the prospective choice of working in the EC context. This effect was independent from mathematics knowledge for working as an EC teacher. Both knowledge facets did not show significant effects on the choice to work in EC institutions.

Table 5.3 Manifest variances (diagonal) and manifest correlations (upper triangular matrix) of the variables included in the model

	Mathematics anxiety	*Mathematics content knowledge*	*Mathematics pedagogical content knowledge*	*Prospective choice of EC education*
Mathematics anxiety	.59	–.39	–.20	.14
Mathematics content knowledge	–	92.67	.43	–.11
Mathematics pedagogical content knowledge	–	–	85.38	n.s.
Prospective choice of EC education	–	–	–	.75

Note: All variances and correlations were significant ($p < .001$), except the correlation between MPCK and CHOICE.

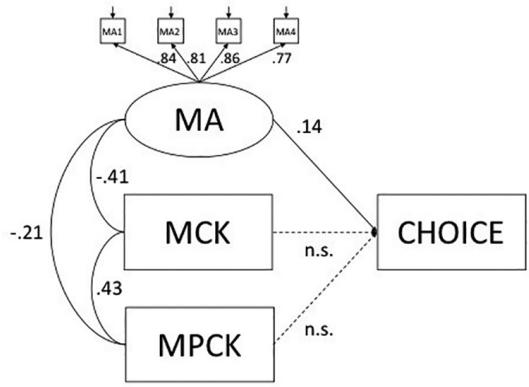

Figure 5.1 Empirical model (standardized solution). *Note*: CHOICE = prospective choice in favor of EC institutions, MA = Mathematics anxiety, MCK = mathematics content knowledge, MPCK = mathematics pedagogical content knowledge.

Discussion

The presented study examined MA as a factor in the career choice of prospective EC teachers.

Previous research showed that MA has negative effects on the choice of a profession in STEM (Chipman et al., 1992; Huang et al., 2018). The present study reveals that mathematics anxious educators are more likely to choose the profession "EC teacher", even if this effect is only of small strength. This could lead to the assumption that EC teacher is indeed *a math-avoidant profession* in Germany. The result of the study is also astonishing as the current study examined the effect of a math-specific construct on general, domain-unspecific, career choice. Thus, the results indicate that the work as an EC teacher is not subjectively seen as a math-specific profession (although mathematics is described as one important domain besides others in the curriculum for EC institutions) – otherwise, it would not make sense that a math-anxious person chooses a math-related career. Nevertheless, the small effect size also indicates that there might be a lot of other aspects that affect the choice in favor of the profession EC teacher (e.g. pedagogical interests).

Unfortunately, the study also shows that the level of mathematics-specific knowledge for EC education (MCK and MPCK) has no effects on career choice: whether educators during their training opt for a career in EC education is independent of whether they have a lot of mathematics content and MPCK.

However, the results of the study must be considered against the background of some limitations and should therefore only be seen as initial empirical evidence. In the present study, only the intentional choice to work in EC institutions was asked and not the actual choice or the motive behind. At least

for Germany, it can be assumed that the work as an EC teacher represents the largest occupational field for trained educators. This means that more participants of the study will work in this area later than they stated in their intention in the study. Longitudinal studies would certainly have been advantageous for the investigation of the research question in order to also be able to causally assess the effects of MA. Nevertheless, the results of the study have to be seen as specific to the German context due to the specifics in EC teacher education (e.g. trained as generalists and, especially, the possibility to choose between the profession *EC teacher* and other professions without a focus on children's education).

Conclusion

According to the state of research, MA can be considered a meaningful phenomenon among EC teachers. One could argue that MA in the EC context might be more relevant compared to the school context, because in the less structured EC education context, the avoidance of mathematical situations is much more likely. This may hinder the development of children's competence in mathematics by EC teachers. However, no effects of EC teachers' MA on children's mathematical competence were found in the reviewed studies. Nevertheless, EC teachers are usually trained as generalists, not only in Germany, and are thus trained only to a limited extent in mathematics with regard to EC education (Blömeke et al., 2017). In addition, this circumstance is reinforced by the fact that the formal barrier to teaching mathematics in EC institutions can be considered very low, which in turn can increase pre-service as well as in-service EC teachers' MA. Consequently, EC teachers have fewer resources to meet mathematical requirements in the sense of the control-value theory (Pekrun & Perry, 2014). More importantly, however, the experience of MA should not be seen as competing with the attitude of EC teachers that mathematics is a valuable domain and can therefore be perceived as positive. With regard to control-value theory, this is rather to be understood as an explanation for the experience of MA (Pekrun & Perry, 2014). In educational research on EC teachers' competence, MA is not conceptualized as a pathological phenomenon, but as a relevant disposition in which EC teachers can differ. Some will certainly experience MA in a significant way. The extent to which this occurs, however, might also depend on the way MCK is trained throughout EC teacher education. The more school-based MCK is conceptualized, the higher the level of MA can be, since teachers' MA is also essentially acquired through negative experiences during their own schooling time (Bekdemir, 2010). Which MCK is needed for the work as an EC teacher, however, must still be considered as something to be examined (Jenßen, Dunekacke, Gustafsson, & Blömeke, 2019b). In any case, it must be stated that based on the overall research body about MA, very little research on MA exists among EC teachers.

In the light of the current state of research, the following aspects should be explored in the future:

- Research on effective training programs, which connect mathematics content with reflection of the individual emotional tendencies towards mathematics
- Relations between MA and math-related epistemic beliefs
- Effects of MA on (pre-service) EC teachers' professional performance (e.g. different teaching styles)
- Research on in-service EC teachers' MA and its effects on their professional development
- MA as explanatory factor for possible discrepancies between higher levels of professional knowledge in mathematics and lower levels in professional performance in math-related activities
- Research with focus on EC teachers' mathematics *teaching* anxiety

Notes

1 Some authors label the physiological facet as "somatic" (e.g. Cooke et al., 2011) and the behavioral facet as "motivational". Besides these facets, the expressive facet is also sometimes characterized.
2 *KomMa* was a collaboration of Alice Salomon University of Applied Sciences and Humboldt-Universität zu Berlin from 2012 to 2015, which was funded by the German Federal Ministry of Education (FKZ: 01PK11002A).

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Appendix A

Items of the questionnaire covering mathematics anxiety (adapted from Lee, 2009)

1 I get very nervous when I have to work on a mathematical task.
2 I worry that I will get wrong results when solving mathematical tasks.
3 I feel helpless when doing a mathematics problem.
4 I worry that it will be difficult for me when working on a mathematical task.