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## Early Childhood Educators' Math Anxiety and Its Relation to Their Pedagogic Actions in Swedish Preschools

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### ABSTRACT

Early childhood educators' math anxiety and its relation to their frequency of pedagogic actions was examined through a questionnaire completed by 352 participants (aged 21–65) representative of the Swedish municipality where the study was conducted. Our sample contained 189 certified preschool teachers and 163 preschool caregivers who significantly differed in their ratings reported for math teaching anxiety. Results revealed that certified preschool teachers who reported higher levels of math anxiety also reported teaching and talking about mathematics content less frequently. When controlling for certified preschool teachers' gender and age, years of work in preschools, and whether they work only with younger (1–3), older (4–6) or with both groups of children (1–6-year-old), certified preschool teachers' general math anxiety and math teaching anxiety predicted their reported frequency of math teaching and frequency of conversations about numbers, patterns, and geometric concepts with peak strength in gatherings, excursions and situations designed to teach mathematics to preschool children. Preschool caregivers' math anxiety measures and their reported frequency of pedagogic actions did not display statistically significant relations. Findings showed setting specific associations between certified preschool teachers general math anxiety, math teaching anxiety and their avoidance of mathematics content, highlighting the importance of early childhood educators' awareness of math anxiety, its nature, and consequences for teaching practices.

Math knowledge is important for school and life outcomes, particularly for career paths in STEM disciplines, where large gender differences in the vocational orientation of adolescents exist (OECD, 2006a, 2012). The decision to choose a STEM career is often driven by stereotypical images of science and technology professions (Luo, So, Wan, & Li, 2021) but also by the content and quality of mathematics education. More specifically, the content of school curriculums, math teachers' ability to transfer math knowledge, and the emotions that teachers express when teaching math have all been shown to affect students' choices of STEM careers (Hannula, 2020; Hill et al., 2008; OECD, 2006a).

Teachers transfer content knowledge but also their own feelings and attitudes toward mathematics to children (Maloney & Beilock, 2012; Mazzocco, 2007). This transfer is especially important to acknowledge for teachers that suffer from math anxiety, that is,

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teachers who report “feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations” (Richardson & Suinn, 1972, p. 551). The highest rate of math anxiety is often reported for early childhood and elementary school teachers (Battista, 1986; Clark-Meeks, Quisenberry, & Mouw, 1982; Geist, 2015; Hembree, 1990; Novak & Tassell, 2017) who work with children at an age in which they are introduced to fundamental mathematical concepts (Gopnik, Sobel, Schulz, & Glymour, 2001; Petronzi, Staples, Sheffield, Hunt, & Fitton-Wilde, 2017) and lay the foundation for their own feelings about math as a subject and people working in STEM more broadly (Li & Schoenfeld, 2019).

### Math anxiety in schools

Math anxiety keeps children and adults away from engaging with mathematical concepts and operations (Ashcraft, 2002). It is a phenomenon globally connected to math performance with prevalence in low math achievers, although, it exists at all math ability levels (Foley et al., 2017) and it has been documented in children as early as 4 years of age (Lu, Li, Patrick, & Mantzicopoulos, 2021; Petronzi, Staples, Sheffield, Hunt, & Fitton-Wilde, 2017). Math anxiety is a problem in schools because it has been identified as a source for individual differences in children’s development of math skills (Vukovic, Kieffer, Bailey, & Harari, 2013).

Students with math anxious teachers (Ramirez, Hooper, Kersting, Ferguson, & Yeager, 2018) tend to exhibit lower achievement in math than students with teachers who are not math anxious. Beilock, Gunderson, Ramirez, and Levine (2010) have shown this effect to be stronger between female teachers and female students, although only female teachers were included in their sample so there was no comparison with male teachers. Other studies have found this effect for both boys and girls from first grade, without clear gender differences (Schaeffer et al., 2021). Teachers with higher levels of math anxiety have been found to project their anxiety onto the expectations that they have for their students’ achievement, and these expectations were found to be lower for girls than for boys (Mizala, Martínez, & Martínez, 2015). These findings suggest that teachers’ math anxiety might be a contributing factor to students’ lower math performance by diminishing students’ exposure to mathematics, and that this might start already at preschool age.

### Math anxiety among young students

The relation of math anxiety and math performance has been studied mostly from year one of primary school onwards. However, differences in children’s math performance are noticeable already by age four (Dowker, 2008). A recent metanalysis by Namkung, Peng, and Lin (2019) indicates that the negative correlation between school age children’s math anxiety and math performance has a similar moderate strength among primary (below 5<sup>th</sup> grade) and secondary (5<sup>th</sup> to 12<sup>ve</sup> grade) groups of students. Preschool age students were not included in that metanalysis, yet the study results indicate that children’s development of math anxiety seems to start early in life. Math anxiety also appears to be associated to factors that are not directly related to mathematics content only, but also to teachers’ instruction methods (Szczygieł & Pieronkiewicz, 2021). It is therefore urgent to find out more about what is happening in preschools, before children reach their first year of school.

Children's math anxiety is linked to their basic numerical and spatial competencies, but also to social factors such as their teachers' anxiety about their own mathematics ability, which in combination, predispose students to shape a negative image of mathematics as pointed out by Maloney and Beilock (2012). In their review paper concerned with math anxiety's onset, risk factors and plausible remediating interventions. More recently, the measurement of 1st graders' math anxiety was found to predict students' math achievement in 3rd grade while controlling for children's number line estimation, a basic numerical competency concerning children's ability to represent numerical magnitude which by itself can often explain a great part of the variance in children's math achievement (Pantoja, Schaeffer, Rozek, Beilock, & Levine, 2020). Moreover, math anxiety is lessened by training students to regulate their anxiety (Passolunghi, De Vita, & Pellizzoni, 2020) and by increasing their practice of mathematics skills (Supekar, Iuculano, Chen, & Menon, 2015). The positive impact of these interventions on young children's math performance and math anxiety suggest that the affective dimension of mathematics anxiety is strongly linked to mathematics performance in children already by their first years of school (Mononen, Niemivirta, Korhonen, Lindskog, & Tapola, 2021).

### **Math anxiety's and teachers' teaching behaviors**

Not much is known about the precise mechanisms through which teachers' math anxiety is manifested in teachers' classroom practices. However similar measures collected from K-12 level teachers' affect such as their spatial anxiety have been found to be negatively associated to both their spatial skills and their use of spatial practices in the classrooms (Atit & Rocha, 2020). Furthermore, teachers' spatial anxiety has been found to influence students' spatial learning (Gunderson, Ramirez, Beilock, & Levine, 2013). While we know very little about teachers' affective relationships to mathematics teaching behaviors in schools, we suspect that teachers' math anxiety might play a role in shaping children's affective relations to mathematics content and learning due to its relation to teachers' behaviors.

In line with this idea, a study by Richland, Naslund-Hadley, Alonzo, Lyons, and Vollman (2020) found small, but statistically significant relations between primary school teachers' mathematics anxiety and their students' mathematics anxiety. When proposed as a contributing factor that impacts students, math anxiety and its possible transference from teachers to students is acknowledged to be influenced by cultural and gender constraints, age of the participants involved and especially, by levels of math knowledge and math pedagogical content knowledge of the teachers (Jenßen, 2022). For example, when Richland, Naslund-Hadley, Alonzo, Lyons, and Vollman (2020) estimated the scores for teachers' math anxiety in their sample, they found relations between teachers' math anxiety, lower teaching confidence, and less pedagogical content knowledge, but no relation to math content knowledge among practicing teachers with higher levels of math anxiety. They hence inferred that the impact of teachers' math anxiety on students' learning might be partly due to teachers' pedagogical practices rather than their levels of math content knowledge only. These findings raise concerns regarding how math anxiety interacts with other factors to impact the teaching and learning of mathematics in preschools.

It is important to get a better grasp of all the relations mentioned in the paragraph above, but it is perhaps urgent to consider teachers' math anxiety as a distinct and multidimensional construct which is so far, only suspected to be related to early childhood educators

teaching practices. Preschool teachers have a strategic role that could help prevent a negative impact of math anxiety in schools and future career choices of students. But to support preschool children in developing positive affective relations to mathematics, we first need to know more about preschool teachers own math anxiety and how it relates to their teaching practices.

## Math anxiety in Swedish preschools

Unfortunately, little is known about whether math anxiety impacts teaching practices in Swedish preschools at all. In the wider literature, early childhood educators' math anxiety has been suggested as a factor that might impact the teaching of math content and hence, possibly hinder the development of math skills in preschools (Dowker, Sarkar, & Looi, 2016; Jenßen et al., 2020). Several arguments suggest that this might be the case. High math anxious adults narrate negative experiences with mathematics linking them to their elementary mathematics teachers (Chavez & Widmer, 1982; Markovits and Patkin, 2021). Beilock, Gunderson, Ramirez, and Levine (2010) propose that math anxious teachers might foster environments where ideas such as "boys are better than girls at math" or "mathematics are difficult" proliferate and predominantly impact female students in comparison to male students already by first grade. These authors suggest that high math anxious teachers might model a fear around mathematics, which harms learning. We believe that these messages might discourage a large portion of students from investing in their own mathematical knowledge and from envisioning a future STEM career.

Preschool teachers are in general less specialized in mathematics content knowledge than teachers working with older children, and their self-reported math anxiety affects how they rate their teaching ability. Moreover, when preschool teachers are less confident about their skills in math, they plan to teach it less often (Geist, 2015). On the other hand, preschools often integrate content and teaching exercises in everyday activities like playing with construction sets (Gejard & Melander, 2018), setting the table for lunch, or matching clothing items to explore mathematical content (Vogt, Hauser, Stebler, Rechsteiner, & Urech, 2018). It is therefore possible that these activities may not trigger math anxiety in early childhood educators, whose own general mathematical knowledge far exceeds the content being taught at this age. However, aiming for math teaching and learning through play (Björklund & Barendregt, 2016; Björklund, Magnusson, & Palmér, 2018) as the Swedish curriculum intends (Swedish National Agency for Education, 2018) requires that preschool teachers not only understand the mathematics content themselves, but also that they feel comfortable explaining it to children in simple terms. To uncover whether math anxiety is an essential challenge in Swedish preschools, a first important step is to assess if it does have an impact on the frequency of preschool teachers' teaching practices.

## Current study

Math anxiety among early childhood educators in Sweden and its possible impact on teaching practices is unexplored. To bridge this knowledge gap, we measured math anxiety levels among Swedish early childhood educators and elicited frequencies of engagement with mathematics content in different preschool scenarios. Our first research question was

concerned with comparing our sample to the population of preschools invited to participate in the online questionnaire to determine our sample's representativeness.

The second research question focused on determining our Math Anxiety and Frequency of Pedagogic Actions scales' reliability. We were interested in finding out more about participants' math anxiety in two categories, their general, personal encounters with mathematics and their anxiety about teaching mathematics. Therefore, we organized our measurement scale to give participants the possibility to rank their emotional, cognitive, and social-evaluative sensations while they themselves perform math calculations, and to capture teachers' anxiety at moments in which they are teaching or talking about mathematics with the children in their groups. We first adapted and field-tested the reliability of the Math Anxiety Scale for Teachers (Ganley, Schoen, LaVenja, & Tazaz, 2019) to obtain a measure of preschool teachers' math anxiety levels. The MAST is a scale previously validated with kindergarten through grade 5 teachers in the United States. A more detailed description of this scale's items is available in the methods section and the whole scale we used (MAST-P) is displayed as Supplementary 2.

Two types of educators, certified preschool teachers and certified caregivers were identified in our sample. Therefore, our third research question focused on detecting significant differences in their ratings of the main constructs assessed with our online questionnaire.

Through our online questionnaire, we elicited participants' frequency of pedagogic actions by asking them to report how often they teach mathematics and how often they engage in conversations about mathematics content with the children in three areas of mathematics: counting, patterns and geometry. According to researchers in early childhood education in Sweden such as Palmér, Henriksson, and Hussein (2016), the pedagogical quality of mathematical activities presented in Swedish preschools, is a responsibility of the certified preschool teachers rather than a responsibility shared with the caregivers that work daily with the same group of children. This organization of responsibilities between preschool teachers and caregivers has been explicit from the introduction of modifications to the Swedish Preschool curriculum of 2010 (Swedish National Agency of Education, 2010). Our fourth research question was hence split in two: 4a. How is math anxiety related to the pedagogic actions of the certified preschool teachers in our sample? And 4b. How is math anxiety related to the pedagogic actions of the certified caregivers in our sample? To the best of our knowledge, this is the first study to directly assess the connection between preschool teachers' math anxiety and their pedagogic actions, providing a critical assessment of whether math anxiety among Swedish preschool teachers impacts the frequency of children's exposure to math content at the very early age when foundations of mathematics are formed.

## Method

In this exploratory study, an online questionnaire was sent to all preschool educators in the local municipality (approx. 1900). The questionnaire was emailed directly to teachers by personnel from the local municipality as part of a collaborative project with the researchers. The collaborative project was concerned with broader aims than those considered in this study. In chronological order, the online questionnaire included collecting a. Demographic information (further described in the data collection measures section), and the ranking of items regarding: b. The relevance assigned to themes present in the preschool curriculum,

c. Teachers confidence level for integrating the goals of the preschool as stated in the preschool curriculum, d. Frequency of activities and practices linked to language and literacy in the preschool e. Mathematics anxiety and frequency of mathematics teaching and talk about mathematics in the preschool.

## Participants

The dataset analyzed in this study corresponds to 352 of 357 preschool educators who provided responses to all sections of our online questionnaire. Participants were allowed to complete the electronic questionnaire during working hours. The last section of the instrument was designed to quantitatively explore the relation between teachers' math anxiety and their pedagogic actions. Five participants did not provide ratings for the math anxiety section and were therefore removed from the analyses. Participation was voluntary and participants were allowed to request to remove their answers without justifying this decision. In total, participants spent an average of fifteen minutes replying to all items in the online questionnaire. No further rewards were offered to the educators in exchange for their response to the online questionnaire.

Our sample contains a broad age range of early childhood educators (ages 21–65) and it includes 189 certified preschool teachers (173 female, 14 male and 2 who identified as non-binary, with a university degree in early childhood education) and 163 caregivers (149 female, 13 male, and 1 who identified as non-binary, with upper secondary education with a focus on children, caregiver certification, degrees from pedagogic courses achieved through adult education or no relevant tertiary level education). For simplicity, we refer to these two groups of educators collectively as “teachers” throughout the current paper. However, a table with the means, standard deviations and tests comparing these two groups across all the measures examined in this paper is presented as [Table 1](#) in the results section.

Early childhood educators in Swedish preschools can be hired either as preschool teachers or as caregivers. In our sample, 347 participants replied to a question regarding their position at the preschools and 5 participants skipped the question. We therefore know with certainty that 187 of our participants are employed as preschool teachers and 160 are

**Table 1.** Descriptive statistics and Mann-Whitney U tests across all measures between certified preschool teachers and caregivers.

Measure	Certification	N	Mean	Median	Stand. Dev.	Min-Max	Mann-Whitney U		
							Statistic	p	Effect Size (r)
General Math Anxiety	Preschool teacher	189	14.97	12.00	7.84	1–35	14347	.308	.062
Math Teaching Anxiety	Caregiver	163	16.05	14.00	8.34	1–35	<b>12117</b>	<b>&lt;.001***</b>	<b>.208</b>
	Preschool teacher	189	12.69	10.00	6.75	1–35			
Frequency of Math Teaching	Caregiver	163	15.20	14.00	7.42	1–35	14331	.264	.063
	Preschool teacher	189	4.03	4.00	0.92	1–5			
Frequency of Math Talk	Caregiver	163	3.88	4.00	0.72	1–5	13990	.164	.086
	Preschool teacher	189	53.52	53.00	8.38	1–75			
	Caregiver	163	54.48	54.00	8.99	1–75			

Note. \* $p < 0.05$ , \*\* $p < .01$ , \*\*\* $p < .001$ .



employed as caregivers. Among our participants, there is a correspondence between teachers being certified as preschool teachers or caregivers and being hired as preschool teachers or caregivers. The mean age for participants employed as preschool teachers who work with children aged 1 to 3 years old was 40.1, and for those who work with children aged 4 to 6 was 41.6. The mean age for participants employed as caregivers who work with children aged 1 to 3 years old was 43.1, and for those who work with children aged 4 to 6 years old was 42.1. The mean age of participants employed as preschool teachers who work with children in both age groups was 44.4 years. The mean age of caregivers who worked with children in both age groups was 47.8 years.

## ***Data collection measures***

### ***Demographic information***

In the first section of our questionnaire, participants were asked to provide information about themselves and the preschools where they work respecting their anonymity, that is their condition of remaining anonymous throughout the completion of the questionnaire. We inquired about participants' age and gender, the type of education they achieved, the number of years they have spent working in preschools and also, whether they were employed as preschool teachers or caregivers assigned to work with children aged 1–3, 4–6, or both groups.

### ***Teachers' math anxiety***

General math anxiety and anxiety about teaching mathematics were measured with a scale of 14 items adapted from Ganley and colleagues' (Ganley, Schoen, LaVenía, & Tazaz, 2019) Math Anxiety Scale for Teachers. We kept the original scale's 4 factor structure, which includes math anxiety's affective, cognitive, and social-evaluative dimensions in its general math anxiety section (items 1–7), and items inquiring about anxiety experienced by teachers while teaching math content in its math teaching anxiety section (items 8–14). The original nineteen items in the MAST scale were modified to better represent plausible scenarios in Swedish preschools and to shorten our instrument. All items were translated by a native speaker and their substantive validity (Supplementary 1) revised by eight mathematics educators and two preschool teacher trainers who are also math education researchers. The process of revision of the MAST-P also resulted in modifications to the MAST response options. The MAST-P asked participants to rank fourteen statements showing their level of agreement on a Likert scale from 1 to 5 (Completely Disagree – Partially Disagree – Neither Agree nor Disagree – Partially Agree – Agree Completely). Statements 1 and 2 correspond to general math anxiety's (GMA) emotionality, the more physiological components in their experiences with mathematics (e.g., My palms sweat, and I feel uneasy when I have to do math calculations). Statements 3 to 5 cover their worry, expressed in the items as thoughts or cognitive components of their affective experiences with mathematics (e.g., I get distracted by other thoughts while I am trying to solve math problems). Statements 6 and 7 inquire about the social/evaluative components of general math anxiety, the items represent situations in which the participants are exposed to others while approaching math tasks (e.g., I feel self-conscious if I don't know how to solve a math problem right away). Statements 8 to 14 describe situations for participants to rate the anxiety they experience while they are teaching or talking about mathematics with the



children (e.g., I worry about making mistakes while talking about math with the children in my group). A table comparing the items in the MAST and the items in our scale (MAST-P) is available as Supplementary 2. This table includes descriptive statistics for the MAST-P items when the averaged data ranked by participants is split according to children's age group. We decided to present teachers' MAST-P rankings in this format as the age groups of children that teachers interact with showed a significant impact on the frequency of certified preschool teachers' math talk, visible in the results section [Table 6](#). Child group 1 includes 122 teachers working with children aged 1–3, Child group 2 includes 153 teachers working with children aged 4–6, and Child group 3 includes 77 teachers working with both age groups, which is aligned with employment assignments in Swedish preschools. Consistent with Ganley, Schoen, LaVenja, and Tazaz (2019) findings, we found that teachers working only with younger groups of children reported higher levels of math anxiety across all items in the MAST-P. Although, it is important to bear in mind that Ganley et al. tested the MAST scale's reliability and construct validity with 399 teachers who work with lower and upper elementary school students (grades k-2 and 3–5, respectively).

### ***Teachers' math-related pedagogic actions***

We first asked participants to indicate how often they teach mathematics providing examples of content present in the Preschool curriculum such as “understanding space, time and form and the basic properties of sets, patterns, quantities, order, numbers, measurement and change, and to reason mathematically about this” and the ability to use mathematical concepts (Swedish National Agency for Education, 2018, p. 15). They ranked the frequency with which they teach mathematics on a Likert scale from 1 (Almost never/never, less frequent than once a month), 2 (rarely, once a month), 3 (occasionally, a few times a week), 4 (often, every day), to 5 (always/more than once a day). On the same rating scale, participants indicated to what extent they talk to children about counting (e.g., recite the count words, count objects in a set, ask the children to count), patterns (e.g., noting that a shirt has red, blue, red, blue stripes) and geometry (e.g., naming geometric shapes). For each of the questions about frequency of math talk, we collected participants' ratings in the following situations: during gatherings, when setting and clearing the table, in the halls when coming in or going out of the classroom, during specific teaching situations designed to teach a particular math concept, and during excursions. The relevance of the situations cited in our instrument to encourage teachers to think about diverse typical Swedish preschool scenarios and the accuracy of the response options in representing frequencies of teachers' pedagogical actions was also discussed with the eight mathematics educators and two preschool teacher trainers who do research in math education. These experts' revision of the MAST-P items and teacher's pedagogic actions frequency scale took place in the same meeting. Every professional was given the opportunity to voice their opinions about the implications of translating the questionnaire statements and response options from English to Swedish to secure the least amount of content loss in this process of adaptation and contextualization.

### ***Substantive validity of MAST-P and teacher's math-related pedagogic actions frequency scale***

After consultation with math educators, teacher trainers and math education researchers regarding the efficiency of our scale to capture teachers' math anxiety and frequency of

math-related pedagogic actions, a few modifications based on their suggestions were made to the scales and their response options. For a detailed description of these modifications, see Supplementary 1.

### **Procedure**

The online questionnaire was shared with teachers at the end of November 2021. Several reminders were sent through the winter and the data collection period ended in February 2022. In Sweden, preschools remained opened throughout the pandemic and the data was collected while daily activities proceeded as usual. The decision to end data collection was made as it coincided with a peak of the COVID-19 contagion and consequential absences of preschool staff due to sick-leave permissions, making it unlikely that many more teachers would participate. All responses were anonymized and tracked by a number code. Explicitly guaranteed anonymity and confidentiality was emphasized in the information provided to the participants before the online questionnaire was started. Our minimization of harm, protection of privacy and respect for autonomy protocols followed guidelines offered by the Swedish Research Council (2017) in accordance with the Declaration of Helsinki (World Medical Association, 2013). Opt-out date ranges and data storage specifications were part of all consent forms approved by the Swedish Ethics Review Authority [approval number: Dnr 2022-01163-01].

### **Data analysis**

As a preliminary analysis, we assessed if our sample was representative in terms of preschools' demographics by comparing respondents to non-respondents. Specifically, we looked at markers of socio-economic status of families attending the preschool, and preschool quality. We computed the quartiles of each population variable and checked whether the distribution between the population and the sample was significantly skewed or not ( $\chi^2$  goodness of fit). We further examined the normality and homogeneity of the distribution of teachers' ratings for the variables General Math Anxiety, Math Teaching Anxiety, Frequency of Math Teaching and Frequency of Math Talk and performed Mann-Whitney U tests to compare the ratings of certified preschool teachers and caregivers within our sample.

In the main analyses, we wanted to address the relation between teachers' math anxiety levels and their frequency of math related pedagogic actions. Thus, we examined the distribution of participant's ratings for all items in the MAST-P. Item-total correlations were then assessed for the General Math Anxiety and the Math Teaching Anxiety sections of the MAST-P. The same procedure was applied to participants' ratings of math-related pedagogic actions: Frequency of Math Teaching and Frequencies of Math Talk. We further assessed the construct validity of the MAST-P through an exploratory factor analysis.

Correlation analyses were performed with the item-level and item-total scores between all variables after examining whether the measures were normally distributed or not, in order to perform parametric and non-parametric tests when appropriate. Reliability estimates were calculated for the variables General Math Anxiety, Math Teaching Anxiety, Frequency of Math Teaching and Frequency of Math Talk in three math areas: counting, patterns, and geometry.

Significant correlations between levels of math anxiety and reported frequencies of math teaching and math talk were followed up with hierarchical regression analyses. These analyses allowed us to control for the effect of demographic variables on the first step of the model and to test if adding math anxiety variables to the second and third steps improved our model's ability to predict the outcome variables Frequency of Math Teaching, and Frequency of Math Talk in the three areas of math. For comparative purposes, we created a fourth model which allows the readers to understand the structure and compare the results contained in the hierarchical regressions models more easily. All the data from the self-reporting scales were analyzed using Jamovi version 1.6 (The Jamovi Project, 2021).

## Results

### *Representativeness of the sample*

Is our sample of respondents' representative of the recruited population? When comparing our sample to the population of preschools invited to participate in the questionnaire, no significant differences were found for the percentages of parents' background in terms of Swedish or immigrant origin (including a subclassification for immigrants who have been in the country for 2–6 years, and more than 6 years). We checked percentages of parents per preschool who were born in High and Low Human Development Index countries, as indicated in the Human Development Index (United Nations Development Programme, Human Development Report, 2019) and the percentages of parents on income support. We also compared percentages of parents at different educational levels (elementary/high school/university/doctorate). Our sample contains responses of teachers from 75 out of 150 preschools in the municipality with above 25% representation of all groups mentioned. Our sample of respondents is slightly underrepresented when it comes to the smallest preschools in the municipality (settings which tend to be composed by less than 10 children per school), preschools with a high percentage of families with Swedish background, and preschools with many single parents.

### *Descriptive statistics and differences between teacher groups across all measures*

Are the two types of educators in our sample significantly different from each other on any critical variables? As our sample of early childhood educators contained 189 certified preschool teachers and 163 caregivers we found it relevant to explore the distribution and differences between their ratings for all the measures examined in this study. After inspecting for violation of the assumption of normality (Shapiro-Wilk tests) and homogeneity of the variances (Levene's test) we decided to performed non-parametric Mann-Whitney U tests between the groups (Table 1). No significant differences were found between certified preschool teachers and caregivers' ratings for the General Math Anxiety, Frequency of Math Teaching and Frequency of Math Talk variables. However, the Mann-Whitney test indicated that the ratings for Math Teaching Anxiety were significantly higher for certified caregivers ( $Mdn = 14.00$ ) than for certified preschool teachers ( $Mdn = 10.00$ ;  $U = 12117$ ,  $p < .001$ ). Although the effect size of this

difference ( $r = .208$ ) is small, we decided to analyze the two educator groups separately in the analyses regarding the relationships between math anxiety and math related pedagogical actions.

**Reliability and construct validity of the MAST-P**

As presented earlier, the constructs general math anxiety and math teaching anxiety are theoretically distinct. The substantive, structural and external validity of the MAST had already been assessed by Ganley, Schoen, LaVenía, and Tazaz (2019). However, as we translated and rephrased a few items of the original scale to suit the characteristics of our participants’ context, we decided to further explore the factorial structure of the MAST-P. All 14 items of the instrument were subjected to an exploratory factor analysis with oblique rotation (oblimin). The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis ( $KMO = .940$ ) and Bartlett’s test of sphericity ( $\chi^2(91) = 4382, p < .001$ ) indicated that the correlation structure was appropriate for factor analyses. The minimum residuals factor analysis yielded a two-factor solution as the best fit for the data, with two factors accounting for 66.6% of the variance. The results of this exploratory factor analysis are presented in Table 2.

The exploratory factor analysis showed that the MAST-P asked all participants to rate their levels of agreement with at least two separate latent constructs, here referred to as general math anxiety and math teaching anxiety. We also assessed the scales’ structural validity by examining item-level descriptive statistics, item-total correlations and reliability estimates to further verify the scales’ reliability and construct validity. When the scale item-total correlations were examined, all correlations were  $> .411$ . Item reliabilities with the 14-item scale taken in its unidimensional form had a Cronbach’s alpha of .951. Measured separately, Cronbach’s alpha for the General Math Anxiety section of the MAST-P was .934 and .930 for the Math Teaching Anxiety section.

**Table 2.** Factor loadings of items, total factor loadings and percentage of variance in MAST-P.

		Factor Loadings		Uniqueness
		1	2	
General Math Anxiety	Item 1		.829	.267
	Item 2		.939	.136
	Item 3		.834	.214
	Item 4		.904	.218
	Item 5		.605	.555
	Item 6		.600	.217
	Item 7		.449	.160
Math Teaching Anxiety	Item 8	.614		.447
	Item 9	.775		.355
	Item 10	.885		.257
	Item 11	.752		.355
	Item 12	.883		.252
	Item 13	.811		.246
	Item 14	.810		.262
SS Loadings		4.853	4.465	
% of Variance		34.66	31.89	
Cumulative %		34.7	66.6	

*Note.* ‘Minimum residual’ extraction method was used in combination with an ‘oblimin’ rotation.

### Reliability of the scale for math-related pedagogic actions

To examine the reliability of the math-related pedagogic actions scale, we examined item-level descriptive statistics and item-total correlations for all participants' ratings of math teaching and math talk frequencies. Frequency of Math Teaching was measured by a single item that was weakly yet positively correlated with the Frequency of Math Talk in the three areas of math  $r(351) = .253, p = .001$ . The scale reliabilities for all participant's ratings of math talk were high for the three areas of math: counting ( $\alpha = .723$ ), patterns ( $\alpha = .826$ ), and geometry ( $\alpha = .825$ ). Furthermore, item reliabilities with the 15-item scale, Frequency of Math Talk, had a Cronbach's alpha of .902. The coefficients between areas of math showed that teachers' math talk ratings were positively correlated between each other. The correlation between math talk frequencies for counting and geometry was  $r(351) = .606, p = .001$ ; between math talk frequencies for counting and patterns,  $r(351) = .607, p = .001$ ; and between math talk frequencies for geometry and patterns,  $r(351) = .722, p = .001$ . Table 3 (for certified preschool teachers) and 4 (for preschool caregivers) display the distributions for the frequencies of math talk in each preschool situation and as composite scores for each area of mathematics (3a, 3b and 3c in Tables 3 and 4).

**Table 3.** Correlation matrix and Descriptive Statistics of Variables for Certified Preschool Teachers (N = 189).

		Correlation Matrix		Descriptive Statistics of Variables				
		1a	1b	$\alpha$	Mean	SD	Min	Max
Pearson's r	Math Anxiety							
	1a. General Math Anxiety			.938	2.14	1.12	1	5
Spearman's rho	1b. Math Teaching Anxiety	.741***		.938	1.81	.964		
	<b>Math-Related Pedagogic Actions</b>							
	2. Frequency of Math Teaching	-.204**	-.192**		4.03	.721	1	5
	3. Frequency of Math Talk in the 3 areas	-.179*	-.243***	.896	3.57	.559	1	5
	3a. Frequency of Math Talk -Counting	-.176*	-.272***	.694	3.87	.582	5	5
	During gatherings	-.164*	-.222**		4.15	.684	1	5
	Clearing table	-.100	-.157*		3.34	1.20		
	Halls	-.051	-.096		3.58	.851		
	Teaching situations	-.236**	-.358***		4.33	.737		
	Excursions	-.172*	-.189**		3.94	.762		
	3b. Frequency of Math Talk -Patterns	-.083	-.108	.809	3.45	.663	1	5
	During gatherings	-.048	-.072		3.59	.735	1	5
	Clearing table	-.063	-.011		2.70	1.16		
	Halls	-.042	-.076		3.64	.756		
	Teaching situations	-.200**	-.297***		3.87	.841		
	Excursions	-.098	-.121		3.43	.839		
	3c. Frequency of Math Talk - Geometry	-.197**	-.269***	.794	3.39	.648	1	5
	During gatherings	-.206**	-.257***		3.57	.793	1	5
	Clearing table	-.084	-.146*		2.92	1.12		
	Halls	-.083	-.133		3.06	.861		
	Teaching situations	-.264***	-.289***		3.95	.787		
	Excursions	-.232**	-.248***		3.44	.760		

Note. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

**Table 4.** Correlation matrix and descriptive statistics of variables for certified caregivers (N = 163).

		Correlation Matrix		Descriptive Statistics of Variables				
		1a	1b	A	Mean	SD	Min	Max
Pearson's r	Math Anxiety							
	1a. General Math Anxiety			.931	2.29	1.19	1	5
Spearman's rho	1b. Math Teaching Anxiety	.707***		.917	2.17	1.06		
	<b>Math-related Pedagogic Actions</b>							
	2. Frequency of Math Teaching	-.073	-.054		3.88	.922	1	5
	3. Frequency of Math Talk in the 3 areas	-.036	-.042	.909	3.63	.600	1	5
	3a. Frequency of Math Talk -Counting	-.008	-.072	.758	3.92	.630	1	5
	During gatherings	-.065	-.140		4.13	.773	1	5
	Clearing table	-.029	-.120		3.65	1.02		
	Halls	.002	.012		3.72	.909		
	Teaching situations	.018	-.006		4.16	.863		
	Excursions	.104	.066		3.94	.836		
	3b. Frequency of Math Talk -Patterns	-.0017	-.018	.841	3.52	.716	1	5
	During gatherings	-.061	-.055		3.70	.842	1	5
	Clearing table	-.039	-.114		3.01	1.09		
	Halls	.049	.114		3.59	.831		
	Teaching situations	.097	.070		3.85	.872		
	Excursions	-.024	.013		3.48	.914		
	3c. Frequency of Math Talk - Geometry	-.051	-.070	.729	3.45	.729	1	5
	During gatherings	-.030	-.023		3.60	.837	1	5
	Clearing table	-.066	-.096		3.18	1.04		
	Halls	-.076	-.070		3.17	.975		
	Teaching situations	.097	.016		3.88	.866		
	Excursions	-.067	-.068		3.43	.825		

Note. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

### ***Relations between certified preschool teachers' math anxiety and frequencies of math-related pedagogic actions***

Is math anxiety related to pedagogic actions for certified preschool teachers? General math anxiety ( $r(188) = -.204$ ,  $p = .005$ ) and Math Teaching Anxiety ( $r(188) = -.192$ ,  $p = .008$ ) correlated negatively with the Frequency of Math Teaching reported by the certified preschool teachers in our sample. These relations were small in terms of effect size, yet significant in both cases.

Among the item-total frequencies of math-related pedagogic actions, we found significant negative correlations between certified teachers' General Math Anxiety ( $\rho(188) = -.176$ ,  $p = .015$ ), Math Teaching Anxiety ( $\rho(188) = -.272$ ,  $p < .001$ ) and how frequently teachers talk with the children about counting. The frequency of math talk in the area of geometry also correlated negatively and significantly with General Math Anxiety ( $\rho(188) = -.197$ ,  $p = .007$ ) and Math Teaching Anxiety ( $\rho(188) = -.269$ ,  $p < .001$ ). No significant relations between General Math Anxiety nor Math Teaching Anxiety and item-total frequencies of math talk about *patterns* with the children were found, though the direction of these correlations were also negative.

When examining the correlation coefficients between the math anxiety measures and the single items contained within the Frequency of Math Talk, there was a consistent pattern for the three areas of mathematics. The associations between math anxiety measures and less math talk were more likely during gatherings, during situations specifically intended for teaching mathematics concepts and during excursions.

### ***Relations between caregivers' math anxiety and frequencies of pedagogic actions***

Is math anxiety related to pedagogic actions for preschool caregivers? Although the same general pattern of negative correlations between math anxiety and pedagogical actions was apparent for caregivers as for certified preschool teachers, the correlations were much weaker and failed to reach statistical significance.

### ***Predictors of math teaching frequency among certified preschool teachers***

Though the correlations between the math anxiety measures and the frequencies of math related pedagogic actions were at best moderate, they were systematically negative and largely statistically significant across all areas of mathematics (Table 3). We therefore decided to follow up these correlations by constructing hierarchical regression models that test whether certified preschool teachers' math anxiety ratings predict the variance in math teaching and math talk frequencies. In the construction of these regressions, we respected the theoretical distinctions between inquiring about teaching mathematics and talking about mathematics with the children.

In the first hierarchical regression, we predicted teachers' Math Teaching Frequency. We included all the demographic variables in Model 1. The coefficient of determination in Model 1 ( $F(6, 182) = 2.22, p = .043, R^2 = .0711$ ) indicated that teachers' gender, specifically being male ( $\beta = .442, p = .038$ ) was a significant predictor of math teaching frequency while controlling for the age group of the children teachers work with, teachers' years of work in preschools and teachers' age. Among the certified preschool teachers in this sample, males (7.40% of the certified preschool teachers) reported to teach math more frequently.

Next, we introduced the variable General Math Anxiety in Model 2. The inclusion of General Math Anxiety ( $\beta = -.0175, p = .014$ ) improved the model's ability to explain the variance in teachers' Math Teaching Frequency. This addition resulted in a  $\Delta R^2$  of .0319, indicating a 3.19% increase in the proportion of explained variance. The change in the F-statistic for Model 2 ( $\Delta F(1, 181) = 6.15, p = .014$ ) further demonstrated the significance of this improvement. The overall fit of the Model remained adequate and continued to be statistically significant ( $F(7, 181) = 2.84, p = .008, R^2 = .103$ ).

In Model 3, we introduced the variable Math Teaching Anxiety. Teachers' gender (being male), which did not retain significance in Model 2 ( $\beta = .388, p = .066$ ), regained its significance in Model 3 ( $\beta = .423, p = .046$ ) alongside the newly added Math Teaching Anxiety variable ( $\beta = -.0162, p = .050$ ). By comparing the coefficient of determination in Models 1 and 3, we see an  $R^2$  change of .020 which indicates a 2% increase in the proportion of variance explained ( $\Delta F(1, 181) = 3.91, p = .050$ ). By this step, the overall Model remained significant ( $F(7, 181) = 2.49, p = .018, R^2 = .091$ ).

Both, General Math Anxiety ( $\beta = -.0158, p = .138$ ) and Math Teaching Anxiety ( $\beta = -.0026, p = .828$ ) were introduced together as step 2 in Model 4 ( $F(8, 180) = 2.48, p = .015, R^2 = .103$ ). When both variables were added together, they did not uniquely predict Math Teaching Frequency. However, together they explained 3.21% of the variance in Math Teaching Frequency ( $\Delta F(2, 180) = 3.91, p = .048, \Delta R^2 = .032$ ). All estimates of the regression models can be seen in Table 5.



**Table 5.** Hierarchical regression results: predictors of math teaching frequency among certified preschool teachers(N = 189).

Overall Model Test									
R <sup>2</sup>	.071( <i>p</i> =0.043)		.103( <i>p</i> =0.008)		.091( <i>p</i> =0.018)		.103( <i>p</i> =0.015)		
F	2.22 (df= 6)		2.84 (df= 7)		2.49 (df= 7)		2.48 (df= 8)		
	Model 1			Model 2		Model 3		Model 4	
R <sup>2</sup> change	-			.032 ( <i>p</i> = <b>0.014</b> )		.020 ( <i>p</i> = <b>0.50</b> )		.032 ( <i>p</i> = <b>0.48</b> )	
F change	-			6.15 (df= 1)		3.91 (df= 1)		3.08 (df= 2)	
Variable	B Estimate (SE)	Stand. Estimate (β)	p	B Estimate (SE)	Stand. Estimate (β)	p	B Estimate (SE)	Stand. Estimate (β)	p
Constant	3.364(.315)		<.001	3.679 (.336)		<.001	3.604 (.335)		<.001
Child Group (both)	172(.138)	.238	.215	.191 (.136)	.264	.163	.160 (.137)	.221	.245
Child Group (younger)	−.103(.123)	−.143	.404	−.044 (.124)	−.060	.724	−.057 (.125)	−.079	.644
Years of work in preschool	−.006(.009)	−.102	.471	−.004 (.009)	−.063	.652	−.006 (.009)	−.091	.512
Teachers' age	.017(.009)	.253	.074	.014 (.009)	.211	.132	.016 (.009)	.233	.098
Teachers' gender (non-binary)	.820(.721)	1.130	.257	.709 (.712)	.977	.321	.851 (.715)	1.173	.236
Teachers' gender (male)									
Teachers' general math anxiety	<b>.442(.212)</b>	<b>.610</b>	<b>.038</b>	.388 (.210)	.535	.066	<b>.423 (.210)</b>	<b>.584</b>	<b>.046</b>
Teachers' math teaching anxiety				<b>−.017(.007)*</b>	<b>−.184</b>	<b>.014</b>	-	-	-
							<b>−.016 (.008)</b>	<b>−.147</b>	<b>.050*</b>
							−.002 (.012)	−.024	.828

### ***Predictors of frequency of math talk in the three math areas among certified preschool teachers***

Another hierarchical regression model was constructed to further explore the negative relations between certified preschool teachers' math anxiety measures and their frequency of math talk. We included the demographic variables in Model 1 ( $F(6,182) = 2.75, p < .014, R^2 = .0865$ ), which indicated that the age group of children certified preschool teachers' work with is a significant predictor of their Frequency of Math Talk in the three math areas. Teachers in our sample who work with both age groups (1–3 and 4–6) reported to talk more frequently ( $\beta = 4.293, p = .007$ ) about math than teachers who only work with the older age group (see Table 6).

The variable General Math Anxiety was introduced in Model 2 ( $F(7, 181) = 3.57, p < .001, R^2 = .1262$ ). Model 2's coefficient of determination showed an increase in the overall model's ability to explain the variance of Math Talk Frequency, with more General Math Anxiety ( $\beta = -.2260, p = .006$ ) and whether teachers work with both child groups ( $\beta = 4.54, p = 0.004$ ) being the significant predictors of up to 13% of the variance of Math Talk Frequency. As pointed out by Model 2's  $R^2$  change of .039 ( $\Delta F(1,181) = 7.86, p = .006$ ).

In Model 3 ( $F(7, 181) = 3.91, p < .001, R^2 = .1367$ ), we introduced the variable Math Teaching Anxiety. Model's 3 change in  $R^2 = .502$  ( $\Delta F(1, 181) = 10.1, p = .002$ ) shows an increase in the overall model's ability to explain the variance in Math Talk Frequency, with more Math Teaching Anxiety ( $\beta = -.2940, p = .002$ ) and teachers' working with both child groups ( $\beta = -4.0761, p = .009$ ) being the significant predictors of up to 14% of the variance in Math Talk Frequency.

Model 4 ( $F(8, 180) = 3.47, p < .001, R^2 = .139$ ) introduced General Math Anxiety ( $\beta = -.0829, p = .491$ ) and Math Teaching Anxiety ( $\beta = -.2227, p = .111$ ) together. When both variables were added together, they did not uniquely predict teachers' Frequency of Math Talk. However, together they explained 5.3% of the variance in Frequency of Math Talk ( $\Delta F(2,180) = 3.91, p = .006, \Delta R^2 = .0526$ ). All estimates of the regression models can be seen in Table 6.

### ***Predictors of frequency of math teaching and math talk in the three math areas among preschool caregivers***

Identical Hierarchical regressions were built with preschool caregivers' demographic information and math anxiety measures to check for predictors of their reported frequencies of pedagogic actions. However, these overall models did not reach statistical significance. They are therefore presented in this paper as Supplementary 3, for further verification and comparison purposes only.

## **Discussion**

Measuring early childhood educators' math anxiety and their frequency of math related pedagogic actions allowed us to explore how these factors might influence Swedish preschool children's exposure to math content. We found that certified preschool teachers who scored higher in the MAST-P reported teaching mathematics less frequently. Certified

**Table 6.** Hierarchical regression results: predictors of frequency of math talk in all areas among certified preschool teachers(N = 189).

Overall Model Test												
R <sup>2</sup>	.086 ( <i>p</i> = <.014) 2.75 (df= 6)			.126 ( <i>p</i> =0.001) 3.57 (df= 7)			.136 ( <i>p</i> = <.001) 3.91 (df= 7)			.139 ( <i>p</i> = <.001) 3.47 (df= 8)		
F												
	Model 1			Model 2			Model 3			Model 4		
R <sup>2</sup> change	-			.039 ( <i>p</i> =0.006) 7.86 (df= 1)			0.502 ( <i>p</i> = 0.002) 10.1 (df= 1)			.052 ( <i>p</i> = 0.006) 5.25 (df= 2)		
F change	-											
Variable	B Estimate (SE)	Stand. Estimate (β)		B Estimate (SE)	Stand. Estimate (β)		B Estimate (SE)	Stand. Estimate (β)		B Estimate (SE)	Stand. Estimate (β)	<i>p</i>
Constant	47.369 (3.617)**			51.436 (3.833)			51.705 (3.782)**			52.144(3.84)		<.001
Child Group (both)	4.294(1.587)	.512		4.544(1.558)	.542		4.07(1.548)	.486		4.22(1.56)	.050	.008*
Child Group (younger)	-.421(1.418)	-.503		.346(1.417)	.041		.404(1.40)	.048		.485(1.414)	.058	.732
Years of work in preschool	-.021(.110)	-.026		.013(.109)	.016		-.009(.107)	-.011		0.000565 (.109)	0.000714	.996
Teachers' age	.124(.111)	.156		.087(.109)	.110		.009(.108)	.125		.092(.109)	.116	.400
Teachers' gender (non-binary)	12.87(8.26)	1.53		11.444 (8.118)	1.366		13.43(8.055)	1.60		12.77(8.12)	1.524	.118
Teachers' gender (male)	1.94 (2.431)	.231		1.246(2.396)	.148		1.596(2.372)	.190		1.425(2.38)	.170	.552
Teachers' general math anxiety				-.226(.080)	-.205		-	-		-.082(.120)	-.075	.491
Teachers' math teaching anxiety							-0.294(.092)	-.230		-0.222(.139)	-.174	.111

preschool teachers' General Math Anxiety and Math Teaching Anxiety stood out as significant predictors of teachers' Frequency of Math Teaching and Frequency of Math Talk in diverse preschool scenarios when the predictors were independently introduced to the hierarchical regression models. However, when both predictors were included in the models they did not each uniquely significantly predict either of the outcome variables, even though when both predictors were introduced to the models they together still explained a statistically significant amount of variance in both math teaching frequency (3.2%) and frequency of math talk (5.3%).

A factor that related to how much teachers talk about mathematics was the age of the children in their groups, with teachers who work with both age categories inquired in our study (1–3; 4–6) reporting to talk more about mathematics than those who only work with the older groups of children. There was also a significant effect of gender in our hierarchical regression that contained Frequency of Math Teaching as an outcome variable, with male teachers teaching math more frequently than female teachers. However, we cannot comment extensively on this gender effect as our sample included a large majority of women (91.4% of the total sample).

Our findings provide information on how higher math anxiety among preschool educators in our sample relates to their teaching practices, and thus diminishes children's exposure to mathematics content in Sweden. To better interpret the scope of our study results, we bring to this discussion the findings of previous research that has also investigated factors that come to influence and interact with the emergence and development of math anxiety in the early years and among teachers.

### ***Frequency of math teaching***

It is likely that the development of math anxiety in children is influenced by social factors such as the interaction with teachers who themselves suffer from it, as well as children's own difficulties in numerical cognition (Dowker, Sarkar, & Looi, 2016; Maloney & Beilock, 2012), number skills (Lindskog, Winman, & Poom, 2017) and arithmetic fluency (Mononen, Niemivirta, Korhonen, Lindskog, & Tapola, 2021). We focused on the relations between educators' math anxiety and their frequency of pedagogic actions since a study by Palmer (2009) that assessed attitudes, notions, and feelings of early childhood educators in Sweden regarding mathematics content and mathematics teaching, suggested a need for interventions that prevent the transmission of teachers' math anxiety to the young children. Our results also expand the findings of Geist (2015) that teachers' negative attitudes toward mathematics diminish their amount of math teaching planning.

The teachers interviewed in Palmer's (2009) study adopted narratives that denoted their mathematical anxiety as a limitation for their daily practice and connected their professional choice of becoming a preschool teacher to their identities as more or less "mathematical." Some teachers in Palmer's study even claimed that they chose this profession to avoid mathematics content as much as possible in their everyday lives. Expanding the evidence for the commonality of this phenomenon among early childhood educators in Sweden, our study showed that those who reported higher levels of general math anxiety and math teaching anxiety also reported to teach mathematics less often.

Furthermore, our findings reinforce the idea that avoidance of math is frequent for individuals who choose a career in early childhood education (Jenßen, 2022) and that it can be traced and related to the pedagogic practices of the higher math anxious in-service preschool teachers in Sweden. Since we found that the more math anxious a teacher is, the less frequently that teacher teaches mathematics content, we propose that children in groups lead by higher math anxious teachers could develop relationships with mathematics content that are negatively affected by this diminished exposure to math content.

### ***Frequency of math talk***

The number of conversations about math taking place between preschool teachers and the children has been found to impact students' math knowledge growth (Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006; Von Spreckelsen et al., 2019). In our study, when we examined the scores for teachers' math talk frequencies, the scenarios: "gatherings" and "teaching situations designed specifically to teach those math concepts" showed negative relations with teachers' math anxiety across all areas of mathematics. For counting and geometry, which represent two of the three math areas we inquired about (the third one being patterns), the scenario "excursions" also showed negative relations with the math anxiety measures. This suggests that there might be high and low math anxiety settings in Swedish preschools, possibly connected to whether teachers are trying to teach mathematics content or if they are just letting it emerge spontaneously from their conversations with the children. Another possibility is that these relations are mediated by factors proposed in prior literature, such as early childhood educators' math content knowledge (Jenßen et al., 2020) and pedagogic content knowledge (Jenßen, Eid, Szczesny, Eilerts, & Blömeke, 2021) for which we have not collected measures.

According to the model we built with Frequency of Math Talk as an outcome, certified preschool teachers that are assigned to work with children aged 1–6 talk about mathematics content more frequently than the group of teachers that only work with older children. We suspect that this might be due to teachers working with both age groups of children being employed in smaller preschools where the pedagogical activities are organized in different manners to approach children of a wider age range within the same preschool groups. Overall, our models only tested the relations displayed in our sample, yet they raised several questions regarding how the frequency of math talk of certified preschool teachers relates to the specific groups of children they are assigned to work with, and whether these factors interact with how anxious teachers feel regarding the exploration of specific mathematic content in the Swedish preschools.

For instance, recent work has shown that K-12 level teacher's spatial skills influence their pedagogical practice (Atit & Rocha, 2020). Atit, et al.'s study found a negative association between teachers' spatial skills and their spatial anxiety, and a positive association between teachers' spatial skills and teachers' use of spatial teaching practices. In Sweden, a study with early childhood educators showed that teacher's pedagogical mathematical awareness is limited concerning spatial aspects of mathematics (Björklund & Barendregt, 2016). In addition, the present Swedish Preschool Curriculum puts emphasis on the idea that children's conceptual and practical understanding of mathematical content should arise from everyday situations (Swedish National Agency for Education, 2018). Therefore, our

findings regarding math anxiety's relation with teachers' math talk, call for further explorative research on teachers' everyday opportunities to integrate their context's resources to specific mathematics content teaching. Children's diminished exposure to math talk in specific math areas could have a negative influence on children's development of math anxiety and their overall learning of mathematics content knowledge. Hence, we believe that avoidance of math content should be openly discussed with pre-service and in-service preschool teachers in Sweden with special attention to the areas of mathematics, and preschool scenarios where relations to preschool teachers' math anxiety were found in our study.

### ***Responsibility for pedagogical quality***

Although the Swedish Preschool curriculum clearly states that the pedagogical quality of the activities presented in the preschool is responsibility of the certified preschool teachers (Swedish National Agency of Education, 2010), a recent study by Cervantes and Öqvist (2021) reported that certified preschool teachers and caregivers in Sweden still view themselves as sharing equal responsibilities in the working team. This is interesting given that no significant differences were found between our sample's certified preschool teachers' and caregivers' reports for general math anxiety. Yet, the levels of math *teaching* anxiety reported by the caregivers in our sample were significantly higher than those of the certified preschool teachers. Our findings initially support Cervantes and Öqvist's findings, in the sense that it is reasonable to expect high levels of math *teaching* anxiety among the caregivers, if they also regard themselves as responsible for the pedagogic teaching quality. However, we found relations between the certified preschool teachers' math anxiety and their frequency of their pedagogic actions, and no relations between caregivers' math anxiety measures and their frequency of their pedagogic actions. We therefore cannot rule out the possibility that math anxiety's impact might be somehow related to, or mediated by how responsible this different groups of professionals view themselves regarding the pedagogic quality of the mathematics content offered at the preschools.

### **Limitations**

The results of our study showed the relevance of taking into consideration preschool teachers' math anxiety in its different dimensions, and its relation to teachers' frequency of pedagogic practices when assessing factors that might influence how preschool children's relationships to mathematics develop in Sweden. Still, several limitations need to be noted.

Firstly, all the data points we collected and compared in this study were elicited from early childhood educators in the form of online questionnaires. This was a cost-efficient strategy to reach out to all professionals in the municipality where the study took place, especially during COVID restrictions and regulations times. However, choosing this methodology meant relying on teachers' good will and ability to self-report how they feel, think and act in relation to mathematics accurately. In general, teachers have long been criticized for not being able to report how they perform in classes with accuracy (Gaete, Gómez, & Benavides, 2018; Hook & Rosenshine, 1979). Yet, research contrasting teachers' self-reports and classroom observations of their instructional practices (Koziol & Burns, 2015) has found that as the questions that teachers reply to become more focused, they can provide

more reliable data regarding teachers' actual classroom practices. To improve the quality of the data we collected, we consulted with math educators, preschool teacher trainers and math education researchers to design questions that would encourage early childhood educators to think about their different encounters with mathematics in their daily practice.

Furthermore, the demographic information was collected at the beginning of the online questionnaire, including a question regarding participants' gender, education background and occupation. We cannot claim that the questions we posted after inquiring for demographic information would not for example, elicit responses through which teachers are trying to present an image of themselves which is different from their daily performance. Yet, our findings did confirm small but significant relations which are consistent with a generalized stereotypical profile of early childhood educators who dislike mathematics and try to avoid teaching it (Ginsburg, Lee, & Boyd, 2008). In addition, for the case of math teaching frequency predictors an effect of gender (being female) consistent with an effect of stereotype threat for females in mathematics (Spencer, Steele, & Quinn, 1999; Steele & Aronson, 1995) was found. However, our MAST-P and frequency of pedagogic actions in mathematics scales were preceded by several other sections inquiring about varied topics such as the relevance assigned to themes present in the preschool curriculum and frequency of activities and practices linked to language and literacy. We therefore believe that asking about demographic first, should not have impacted teachers' math anxiety nor frequency of pedagogic practices reports. Besides, in our sample, the overall scores of teachers' self-reported math anxiety tended to be below the mid-point of our Likert scales, and the frequency of mathematics related pedagogic actions reported was for the most part above the mid-point thresholds. Hence, if there was an over or underestimation connected to gender or occupation stereotypes in the self-reports we collected, the data seems to still have allowed us to capture a systematic small effect of math anxiety on preschool teachers' practice in Sweden.

Secondly, teachers' anxiety toward mathematics early in the COVID-19 pandemic might have been affected by additional factors such as teachers' general distress levels (Keleynikov et al., 2022). In the current study, we only examined how teachers' self-reported math anxiety and their frequencies of pedagogic practices were linked at one time point, so the reported results are cross-sectional and correlational in nature. Additionally, noting the frequency with which mathematics content is taught and talked about as we did in our study is not the same as assessing teaching behavior or quality directly (Mayer, 1999). Regardless of these limitations, the findings we reported extend the literature on the intensity and characteristics of preschool teachers' math anxiety in Sweden. All data collection instruments were adapted to suit the context yet, it is important to compare the findings of our study with future research that applies methods that go beyond questionnaires to inspect teachers' math related practices in Swedish preschools.

Thirdly, while more detailed aspects regarding the nature of preschool teachers' math anxiety with implications for early childhood education programs can be inferred from the items contained in the MAST-P, this was not investigated in the current study. The MAST-P has shown value in helping us distinguish how teacher's general mathematics anxiety and their anxiety about teaching mathematics relate to their reports of less frequent math teaching and math talk. Future research on math anxiety in preschools could benefit from further exploring teachers' math anxiety following these constructs' distinctions



with the help of the MAST-P. For example, the MAST-P can be used to identify which emotional, cognitive, and social-evaluative aspects of Swedish preschool teachers' math anxiety are more prominent in a group, and to test if teachers' anxiety about teaching mathematics diminishes as a result of interventions targeting their general math anxiety or not. Furthermore, using the MAST-P to measure math anxiety in combination with instruments that allow measuring teaching behaviors, and child outcomes for mathematics knowledge growth across the preschool years would also increase our understanding of teachers' math anxiety on children's learning processes. If negative effects are identified for children's outcomes, interventions could be implemented to lower teachers' math anxiety and assess whether these bring benefits for children's mathematics learning outcomes.

## Conclusion

There is broad agreement in academia and society on the relevance of early mathematics skills development and research has shown that early childhood differences in math performance are associated with future academic achievement (Duncan et al., 2008). In Sweden, the preschool curriculum has increased the specificity of its requirements regarding math content and competencies. However, the term "teach" is arguably a relatively new concept for those working in preschools in Sweden, where a tradition of "learning through play" and "play-based which is compatible with a goal-oriented practice" (Björklund, Magnusson, & Palmér, 2018) is predominant. The preschool teacher is now expected to view mathematics as content, and doing mathematics with the children as a goal for the preschool education. Importantly though, less has been said about how teachers should accomplish these goals. These potential inconsistencies in the preschool curriculum and preschool pedagogical traditions could have serious implications for our participants' ratings of math teaching and math talk frequencies. For example, it could be argued that inquiring about mathematics teaching frequency is asking about a pedagogic action which is regarded in general, as an infrequent occurrence in preschools. In our study, we were able to make more inferences regarding the frequency of math content delivery by asking teachers how frequently they talk about mathematics in specific areas, rather than just inquiring about teaching frequency. Above and beyond this terminology and theoretical distinctions, we agree with the perspective that mathematics teaching in preschools should rightfully continue to be merged and integrated with children's play at this age.

Heightened levels of math anxiety have negative implications such as fear, avoidance of math content, perceptions of low ability and confusion in preschool children (Petronzi, Staples, Sheffield, Hunt, & Fitton-Wilde, 2017). There have not been prior experimental demonstrations of direct relationships of math anxiety with avoidant behaviors toward math content among early childhood educators in Sweden, and this evidence is necessary to elucidate ways to confront the implicit negative effects of math anxiety, such as individuals distancing themselves from mathematics content or students choosing a career path in the STEM fields. We found that teachers' higher levels of math anxiety are related to lower frequencies of pedagogic actions, in other words: preschool children's diminished exposure to mathematics content. More frequent avoidance of mathematics content related to anxiety was seen in situations designed to teach mathematics, and in gatherings, but avoidance was also apparent in scenarios in which conversations about mathematics have a starting point in children's everyday activities, such as excursions.

Our findings also suggest that other factors such as teachers' gender and children's age play a role in the amount of time devoted to mathematics by early childhood educators in Swedish preschools. Further, teachers' general math anxiety and math teaching anxiety showed relations to teachers' frequency of math teaching and math talk with different strengths. For the case of certified preschool teachers, the relations were significant, whereas for the case of certified caregivers they were not. It is thus vital to reflect on adjustments in early childhood education and training interventions that can help both certified preschool teachers and caregivers mitigate the avoidance of math content.

Finally, there is a need for more exploration on how teachers' pedagogic actions influence the differences in children's math anxiety (Petronzi, Staples, Sheffield, Hunt, & Fitton-Wilde, 2017) and math achievement (Cargnelutti, Tomasetto, & Passolunghi, 2017) visible in children by age 4. Further research is required to get a better sense of how teachers' math anxiety hinders the learning of mathematics content. However, examining the items imbedded in the Math Anxiety Scale for Teachers of Preschools strongly indicates that the teachers who are teaching and talking about mathematics less frequently do so to a certain extent because they do not feel completely comfortable teaching mathematics at this level and dealing with mathematics content themselves.

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## Declaration

The authors confirm that the data supporting the findings of this study is available within the article and its supplementary materials.

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