

Pre-service Elementary School Teachers' Expectations about Student Performance: How their Beliefs are affected by their Mathematics Anxiety and Student's Gender.

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Abstract

Using a survey-experiment methodology we evaluate whether elementary school pre-service teachers' beliefs about students' future mathematics achievement and general academic achievement are influenced by teachers' mathematics anxiety level, or by gender and socioeconomic status of the student. We found that mathematics anxiety can negatively influence pre-service elementary school teachers' expectations about students, and that participants assign lower expectations of future mathematics achievement to girls than boys. The two effects, however, appear to be strictly independent as we did not find statistically significant interaction effects between pre-service teacher's mathematics anxiety and the biases associated with student's gender.

Keywords: Mathematics anxiety, Pre-service teachers, Teachers' expectations, Math gender bias, Survey-experiment methodology

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1. Introduction

Mathematics anxiety can be defined as state of tension caused by performing mathematical tasks or taking part in situations that involve mathematics. The concept itself has played a substantial role to understand and advocate the importance of the emotional aspects of mathematics education. Students with high mathematics anxiety tend to avoid homework and courses that involve mathematics, thus limiting their opportunities to learn and early foreclosing certain career paths. Psychological research has also shown that mathematics anxiety has a direct effect on the cognitive processes behind mathematical problem solving. More generally, there is wide consensus on the negative effect of mathematics anxiety in mathematics achievement. For this reason, the phenomenon has gathered increased attention from scholars and mathematical educators over the last decades.

Teachers represent a key actor to develop sustainable solutions to decrease mathematics anxiety, mainly because math anxious individuals often recall negative experiences early in elementary school as one of the most relevant antecedents to their negative attitudes toward mathematics. Even more worrisome, mathematics anxiety is highly prevalent among students enrolled in teaching education programs, especially pre-service elementary school teachers. In fact, most studies performed on teachers or pre-service teachers have associated mathematics anxiety to low teaching self-efficacy and/or lesser mathematical knowledge, tacitly assuming math anxious teachers engage in teaching practices that are detrimental to their students. Yet few studies explore how mathematics anxiety actually affects the skills and characteristics that effective teaching requires. For instance, we found no studies that evaluate how a teacher's mathematical anxiety level can affect their capacity to make unbiased judgments about their students, or how mathematics anxiety relates to commonly held gendered stereotypes.

This paper attempts to fill this gap using an experimental setting in a Chilean sample of pre-service elementary school teachers. First, we evaluate whether pre-service elementary school teachers' beliefs about students' future mathematics achievement and general academic achievement are influenced by pre-service elementary school teachers' mathematics anxiety level, or by gender and socioeconomic status (SES) of the student. Second, we examine if pre-service elementary school teachers' perceptions of students' need for academic support are similarly affected by their own mathematics anxiety or students' characteristics. Finally, we explore the presence of interaction effects between the pre-service elementary school teachers' mathematics anxiety and student's gender.

Our paper proceeds as follows. The next section describes the literature on mathematics anxiety and teacher-student expectations, introducing the question about the interaction between both phenomena, and then presents the general features of elementary school teacher education in

Chile. Section three presents the data, variables and methods. Section four presents robustness checks to evaluate the validity of the experimental design, and the multivariate analysis of variance of the pre-service elementary school teachers' beliefs about students. The final section concludes and discusses both the implications and limitations of our findings.

2. Literature review

2.1 Research on mathematics anxiety

Academic concern about mathematics anxiety date back to the 1950s (Gough, 1954; Dreger & Aiken, 1957), but research on mathematics anxiety began to gain popularity with the development of the first questionnaire to measure it objectively. Richardson and Suinn's (1972) influential article presented the psychometric properties of the Mathematics Anxiety Rating Scale, a 98 items scale composed of brief descriptions of behavioral situations involving mathematics. In this study, mathematics anxiety was defined as "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". Later adaptations (Alexander & Martray, 1989; Ashcraft & Kirk, 2001) and new approaches to measure mathematics anxiety (Hopko et al. 2003) have contributed to a deeper understanding of the complexity of this phenomenon, with new measurement models considering a multi-dimensional construct, for instance, a three-factor structure that separates mathematics tests anxiety, numerical task anxiety and mathematics course anxiety (Alexander & Martray, 1989).

Two independently conducted meta-analysis have demonstrated that mathematics anxiety has a significant negative correlation with mathematical performance and achievement, consistent across gender, grade levels and ethnic groups (Hembree, 1990; Ma, 1999). Some authors attribute the achievement gap to avoidance of mathematics and learning opportunities: highly math anxious individuals take fewer mathematics electives courses than low-anxiety groups, both in high school and college (Hembree, 1990; Scarpello, 2005). In the context of cognitive research, mathematics anxiety was associated with working memory deficits, independent of the individual's overall competence in mathematics (Ashcraft & Moore, 2009). Using a "dual task" method commonly used in cognitive psychology, Ashcraft & Kirk (2001) show that high math-anxious participants present deficits in working memory during simple two-column addition exercises. In this line of research, a recent study conducted on young children confirmed that the negative effect of mathematics anxiety on performance was more pronounced among children with higher working memory, who relied on memory-intensive strategies to solve mathematical problems (Ramírez et al. 2013).

An emerging trend in the literature has focused specifically on the presence of mathematics anxiety among educators. Studies conducted on college settings have consistently found that education majors show a higher prevalence of mathematics anxiety than those in any other field

(Baloglu & Koçak, 2006; Bessant, 1995, Hembree, 1990). More specifically, Hembree (1990) pointed out that university level students who were majoring in elementary education presented the highest levels of mathematical anxiety among the 7 majors included in the meta-analysis. In pre-service elementary school teacher, mathematics anxiety is strongly and negatively related to math teaching efficacy beliefs (Bursal and Paznokas, 2006; Swars et al. 2006; Gresham, 2008). The high prevalence of mathematics anxiety among future teachers is also crucial considering how teachers might transmit their anxieties to their students (Beilock et al. 2010; Conrad & Tracy, 1992; Sloan et al. 2002; Vinson, 2001; Wood, 1998). Beilock et al (2010) studied elementary school teachers and found that the more math anxious a female teacher is, the more likely their female students endorse gendered mathematics stereotypes. By the end of one school year, those girls who believed that “boys were better at math than girls” actually presented worse mathematics achievement than the rest.

The relationship between mathematics anxiety and gender is a matter of great interest and has been extensively researched, but results have been inconclusive. Regarding levels of mathematics anxiety, many studies have found higher levels in females than males (Wigfield and Meece, 1988; Yüksel-Şahin, 2008; Baloglu and Kocak, 2006; Woodart, 2004), yet other researchers have found no significant gender differences (Newstead, 1998; Chiu and Henry, 1990; Chinn, 2009; Devine et al. 2012). There have also been studies evaluating the existence of gender differences in the relationship between mathematics anxiety and performance, again with mixed results (Betz, 1978; Miller and Bichsel, 2004; Birgin et al. 2010). A question that has not yet been addressed by the literature is whether mathematics anxiety increases the chances of gendered stereotype threat in the field of mathematics.

2.2 Research on teacher expectations

The study by Rosenthal & Jacobson (1968) is largely credited for introducing the concept of self-fulfilling prophecies to the field of education. An intelligence test was applied to a sample of children from an elementary school, and then teachers were told that some students (actually randomly selected) had been identified as “bloomers” and would experience great intellectual growth over the upcoming school year. After one year, students labeled as “bloomers” showed IQ gains relative to controls; an effect attributed to the self-fulfilling power of teachers’ induced expectations. Although several critiques were made against the research methodology and results’ interpretations –especially against the bold claim that IQ is affected by teacher expectations (Wineburg, 1987)–, the study inspired more research on teacher expectations and their influence on educational attainment. Two studies that undertook cumulative research on the subject through meta-analysis (Rosenthal & Rubin, 1978; Raudenbush, 1984) supported that expectation effects indeed exist, but the average size of the effect is rather small (binomial effect size of 0.1 to 0.2). An alternative interpretation of Rosenthal (1984) suggested that self-fulfilling prophecies affect the achievement of about 5-10% of all students in a given class. However, under some circumstances these effects may be larger. Some teachers are more prompt than others to behave differently with high- and low expectancy students (or their expectation cues are more salient to

children), thus leading to higher expectancy effects (Brattesani et al. 1984; Kuklinsky & Weinstein, 2001). Also, students from stigmatized demographic groups –such as African American students or lower class students– may present stronger self-fulfilling prophecies (Jussim et al. 1996). In sum, while still meaningful, accumulated evidence indicates the effects of teacher expectations should not be easily generalized.

Analyzing the mechanisms behind expectations effects, Kuklinsky & Weinstein (2001) state that direct effects on achievement may occur through differential teaching practices (giving more opportunities to respond, or more verbal and non-verbal feedback to high-expectancy students) and differences in curricular design (teaching more content and more challenging content to higher expectancy students). Additionally, indirect effects may occur when differences in teachers' behavior influence the development of students' own self-image and performance expectations (Kuklinsky & Weinstein, 2001). In a longitudinal study Mistry et al. (2009) propose and find support for another indirect effect of teachers' expectations, through the influence on students' mothers and future teachers expectations.

Research has also addressed the direction of the expectation effects, comparing the effects of positive and negative expectations. Understandably, self-fulfilled prophecies may work in one of two opposite directions: either harming student achievement by means of low-expectancies, or lifting it up with expectations higher than students' abilities. While most research has intentionally focused on one type of effect, a few studies have attempted to compare the relative power of both (Sutherland and Goldsmith, 1974; Madon et al., 1997). Working with a sample of mathematics teachers and students, Madon et al. (1997) found that the relationship of teacher expectations to student achievement was about three times higher when comparing the highly overestimated group to the underestimated group.

The type of expectation effects discussed here are only meaningful in scenarios where teachers' perceptions of student abilities are inaccurate, in the sense that they differ from an objective measure of performance. Ready and Wright (2011) offer a framework to operationalize the concept of expectation accuracy, distinguishing three possible scenarios. If teacher's perceptions of students' skills are consistent with objective assessments, they are accurate and unbiased; if teacher's perceptions differ from objective measures in a random manner, perceptions are inaccurate but unbiased; but if teacher's perceptions differ systematically from objective assessments based on students' characteristics, one might conclude that perceptions are inaccurate and biased.

Educational psychologists have established that most of the time teachers' expectations are largely, but not completely accurate (Jussim & Harber, 2005). A first wave of research used a cross-study perspective to measure the accuracy of teachers' perceptions (Jussim et al. 1996). The authors considered the average of the correlations between teachers' expectations and students' achievement found in previous studies, and the average size of the expectation effects found in experimental settings; by subtracting the two terms the authors established indirectly that

teachers' perception are about 75% accurate. But as Ferguson (2003) notes, one should focus on the inaccuracy of the predictions in a "glass half empty" fashion. That is, if the remaining variance stems from systematic variation based on students' characteristics, then some level of perception bias takes place.

In this study we attempt to integrate two lines of research in order to answer previously unaddressed questions about mathematics anxiety and gender stereotypes. We use expectation constructs and methodologies to study how mathematics anxiety and gender stereotypes influence pre-service elementary school teachers' opinions about students. We seek to answer the following questions: How does pre-service elementary school teachers' mathematics anxiety and student's gender affect the expectations over students' future achievement? How does pre-service elementary school teachers' mathematics anxiety and student's gender affect the perceived need for students' support? Are gender stereotypes about mathematics stronger in math anxious individuals?

2.3 Elementary school teacher education in Chile

Elementary school teachers in Chile are generalists and have to teach several subjects, including mathematics. Teacher education in Chile is almost entirely delegated to universities. It is also highly decentralized and has experienced major growth over the last decades. During the 1990s, there were few universities providing teacher education programs for basic education teachers and most of them were publicly funded. In 2012, over 94,000 students were enrolled in teacher education programs across 55 universities. Universities are autonomous to set their own admission requirements, which results in a varying degree of selectivity: in 2012, 15% of the education students enrolled attended highly selective research universities, 35% studied in non-research universities with moderate degree of selectivity, while most of the students (50%) attended programs in low selectivity non-research universities.

The programs are concurrent and last on average 9 to 10 semesters and their curriculum content are relatively similar, providing opportunities to learn general education and pedagogy, subject-matter knowledge, and field experience.¹ A four month or semester-long practicum is usually required in addition to the courses. Once students obtain a teaching entitlement from a qualified institution, they are ready to apply for a teaching position on a school on the public or private sector.

In regards to teachers' initial training in mathematics, international comparisons suggest that

¹ TEDS-M defined a *concurrent* teacher preparation program as a single program that included studies in subjects future teachers would be teaching (academic or subject matter preparation), studies of pedagogy and education (pedagogical and professional studies), and practical experience in the classroom.

Chilean initial training system is performing poorly. The international study Teacher Education and Development Study in Mathematics (Tatto et al. 2012) compared the mathematics content knowledge (MCK) and mathematics pedagogy content knowledge (MPCK) of representative samples of future teachers from 17 countries. Chilean future teachers performed poorly on both tests, placing Chile second to last among the evaluated countries. The same study also compared countries' quality assurance mechanisms for teacher training, considering: a) the entry process into teacher education, b) accreditation of teacher education programs, and c) the entry process into the teaching profession. Results on this area were also negative, placing Chile among the countries with a low-strength quality assurance system. The government has pushed new programs (such as, Programa INICIA) aimed at improving initial teacher training through the setting of standards, national tests to measure the content and pedagogical knowledge of future teachers (which in the future would be a requirement to teach in the public sector), and improvement of teacher education programs. In this context, the present study also contributes to a collective effort to deepen our understanding of initial teacher training in mathematics and to improve their quality.

3. Methods and data

3.1 Experimental design

The research design is based on a survey-experiment methodology previously used to study the effects of student level variables on teachers' expectations (Tournaki, 2003; Tournaki & Podell, 2005; Auwarter & Aruguete, 2008a, 2008b; Del Río & Balladares, 2010). In the experiment's standard setting each participant is asked to read one paragraph describing an elementary school student with apparent behavioral difficulty and underachievement in mathematics, and then participants complete a questionnaire about the student, as if s/he were their pupil. The student's gender and socioeconomic status are systematically varied to produce four experimental conditions randomly assigned to each participant: high-SES boy, low-SES boy, high-SES girl and low-SES girl. Gender is varied by using different names ("John" or "Johanna") and corresponding pronouns, while socioeconomic status is implied by altering the occupations of the student's parents. Other than the mentioned manipulations, descriptions are identical (See a sample description paragraph in Appendix). We add mathematics anxiety as pre-service elementary school teacher level independent factor, in order to complete the experiment design to address our research questions. We use three-way ANOVA models to evaluate main and interaction effects of mathematical anxiety and gender stereotypes, while controlling for expectation biases induced by the socioeconomic status of the children.

3.2 Participants

Participants were 208 pre-service elementary school teachers recruited from Chilean universities. E-mail invitations to participate in the study were sent to over 1000 students enrolled in

elementary school education programs in 17 Chilean universities, representative of all three types of universities (highly selective research universities, non-research universities with moderate degree of selectivity and non-research universities with low selectivity). From these, 208 provided their informed consent and completed all questionnaires (approx. 20% completion rate). Students from highly selective research universities and non-research universities with moderate degree of selectivity were over represented in the final sample (40% and 41% respectively) and only 19% of the sample came from less selective universities. The sample included 176 (84.6%) women and 32 (15.4%) men, which is representative of the gender participation in teacher preparation programs. Eighty-six (41.5%) participants were on their first year, 55 (26.1%) on their second year, 44 (2.3%) on their third year, 18 (8.7%) on their fourth year, and 5 (2.4%) on their final year. Participants' teaching experience was mixed. About half of the sample (54.4%) has taught in schools under supervision, but only 18 (8.7%) students had worked in schools as teachers.

3.3 Questionnaire and measures

Participants rated hypothetical students on multiple 5-point likert-type statements. In order to gain more specific insights about pre-service elementary school teachers' judgments, we depart from previous literature (Auwarter and Aruguete, 2008a, 2008b; Del Rio and Balladares, 2010) in the manner we group items into scales. Future expectations for a student are divided in two separate scales: *expectations of mathematics achievement* (including items "This student's mathematics grades will not improve in the future" and "This student will not perform well in mathematics classes") and *expectations of general academic achievement* (including items "This student will probably perform poorly on standardized tests" and "The student's chances of dropping out from high school are high"). These negatively phrased items were reverse coded so that higher values represent higher expectations.

Perceptions of student's need for academic support were also divided in two separate constructs: *need for academic support* (including items "This student could benefit from extra tutoring in math" and "This student could probably benefit from a math buddy") and *need for special education* (including items "The best placement for this student is a special education class" and "The best placement for this student is a special education school").

All scales were calculated as the mean of their corresponding items. Two questions were included to check whether manipulations were perceived as intended: perceived SES of the described student was rated with a single item scored on a 5-point semantic differential, ranging from poor to wealthy, and credibility of the case was evaluated with a single item ("There are real children in the scenario I read") scored on a 5-point likert scale (higher scores represent higher credibility).

Mathematics anxiety of pre-service elementary school teachers was measured with the abbreviated mathematics anxiety rating scale (A-MARS, Alexander & Martray, 1989). The instrument was chosen among a range of mathematics anxiety instruments because of its length,

strong psychometric properties and fit with the study's population. The A-MARS is a 25 items, 5-point likert-type instrument. Two items were dropped in the translation and adaptation of the scale for this Spanish-speaking sample. The final 23 items presented excellent internal consistency with Cronbach alpha =0.94. A composite summative index was calculated and later standardized to adjust a 0-100 scale, in which 0 represents the minimum theoretical score and 100 represents the highest theoretical score. As no norm was available for Chilean samples, final scores were dichotomized around the sample median value (44.4) to distinguish low and high-mathematics anxiety levels.

3.4 Data analysis

We use three-way full factorial ANOVA models to test our hypothesis. ANOVA allows us to explore the relationship between several categorical independent variables (in this case, mathematics anxiety level, student's gender and student' socioeconomic status) and a metric dependent variable, including the interaction effect between the independent variables. The model uses a statistical test based on the ratio of between groups' variance and the error variance (within group variance); significant p values of the test reject the null hypothesis that the means of the dependent variable are equal across groups. We present multiple ANOVA models, one for each dependent variable in our study: expectations of mathematics achievement, expectations of general academic achievement, need for academic support, and need for special education.

4. Results

First, we perform robustness checks to assess if the experimental conditions were perceived as intended. Credibility of the students' descriptions was analyzed and a minimum criterion of 4 points ("agree" with the credibility statement) was established to ensure internal validity. Most participants rated the scenarios as believable and only 14 participants (6.7%) presented ratings below the cutoff point. Those cases were filtered out for subsequent analysis, resulting in a final sample of 194 participants that present a very high case-credibility average (Mean=4.68, Standard Deviation (SD) = 0.47). The final distribution of participants across conditions is presented in Table 1. We also used an ANOVA analysis to establish that believability was stable across the manipulated variables. We found that no particular case description was deemed as more believable than the others, ($F(3,190) = 1.975, p = 0.119$). The manipulation of SES was also perceived as intended. We analyzed the scores of the poor-wealthy semantic differential, where 1 represents "poor" and 5 represents "rich". The participants assigned to low-SES descriptions averaged 2.2 in the semantic differential, significantly lower than the mean of 4.14 points for the high-SES group ($t(192) = 17.3, p < 0.001$).

--- Table 1 ---

Another set of preliminary analysis addressed whether mathematics anxiety constitutes a separate phenomenon from other dimensions of mathematics competency and attitudes in our sample. We performed correlational analysis between mathematics anxiety, mathematics performance (measured by pre-service elementary school teachers' performance on the mathematics section of the standardized admission test PSU) and mathematics self-efficacy (self-rated in a scale from 1 to 5, where higher scores mean a higher sense of mathematics self-efficacy). Our results are in line with previous research and suggest that mathematics anxiety is correlated but distinct from other math-related measures (Table 2). Pre-service elementary school teachers with higher mathematics anxiety levels show significantly lower mathematics self-efficacy ($r = -0.196$, $p < 0.01$), but there was no significant correlation between mathematics anxiety and performance ($r = -0.104$, $p = 0.272$).

--- Table 2 ---

4.1 Main effects analysis

We now turn our attention to our first research question: Which variables affect the expectations over students' future achievement?. We find that expectations of *future mathematics achievement* differ significantly as a function of student's gender, pre-service elementary school teachers' considered that boys would have better mathematics performance (Mean= 4.4, SD= 0.71) than girls (Mean=3.99, SD= 0.86), $F(1, 189)=10.4$, $p < 0.01$ (Table 2). Pre-service elementary school teachers' mathematics anxiety level also had a statistically significant effect on the expectations of future mathematics performance: pre-service elementary school teachers with math anxiety above the median assigned lower expectations (Mean= 4.01, SD= 0.85) than the below the median group (Mean=4.38, SD=0.73), $F(1, 189)= 7.7$, $p < 0.01$ (Table 2). However, the mathematics anxiety of the participants did not affect their expectations about the students' *general academic achievement*, which we interpret as a confirmation that mathematics anxiety is a very specific phenomenon and it should not be confused with general anxiety (Table 3).

--- Table 3 ---

In the *general academic achievement* model we find that student's gender presents a statistically significant effect, following the previously observed pattern: again, boys were assigned higher expectations (Mean=4.24, SD= 0.78) than girls (Mean=3.96, SD= 0.84), $F(1,189)= 5.0$, $p < 0.05$ (Table 2). This result means that pre-service elementary school teachers extrapolate current underperformance in mathematics to general academic underachievement only for girls. There was also an effect for student's socioeconomic status on general academic achievement: expectations for students of high-SES (Mean=4.22, SD=0.81) were higher than for the low-SES students (Mean=3.98, SD= 0.82), $F(1,189)= 5.2$, $p < 0.05$ (Table 2).

We should highlight that our results confirm a significant bias against female students. Our methodology presented cases featuring both male and female students underperforming in mathematics, but pre-service elementary school teachers considered that only in the case of girls

these difficulties with mathematics would have long-term consequences in their general academic achievement. In order to double-check this result, we repeated our experimental methodology in a new sample of pre-service elementary school teachers, but this time we presented hypothetical cases that featured students experiencing difficulties with language classes. In this case we found no significant effects of students' gender in the expectation of general academic achievement (Table A1 in the Appendix), that is to say, pre-service elementary school teachers' extrapolation of current underachievement to more general academic problems in the future, only happen in the domain of mathematics.

With regards to our second research question, we find that different variables exert influence in each support strategy. The analysis on *academic support*, characterized by extra tutoring and peer-based strategies, shows a small but statistically significant effect for student's SES. Pre-service elementary school teachers are more eager to recommend such support strategies to low-SES children (Mean=3.93, SD= 0.66) than to their high-SES counterpart (Mean=3.68, SD=0.79), $F(1,188)=5.21$, $p<0.05$ (Table 2). When it comes to recommend the derivation of the students to *special education*, we find that the level of mathematics anxiety is the only significantly influential factor. Pre-service elementary school teachers above the median on mathematics anxiety are more prone to *special education* strategies (Mean=1.68, SD=0 .83) than the below the median counterparts (Mean=1.36, SD= 0.57), $F(1,189)=8.39$, $p<0.001$ (Table 2). The fact that mathematics anxiety increases the chance of choosing *special-education* alternatives for children adds a new dimension to the teaching consequences of mathematics anxiety. While previous literature has shown that mathematics anxiety might influence specific instructional practices (Bush, 1989; Karp, 1991), our findings suggest that it may also impact attitudes towards classroom inclusion and inclusive practices.

4.2 Interaction effects between pre-service elementary school teachers' mathematics anxiety and student's gender

Finally, we analyze the interaction terms in our models in order to evaluate whether gender stereotypes are augmented by mathematics anxiety. If such effects are significant, we expect that bias on expectations against girls is more pronounced among the pre-service elementary school teachers with mathematics anxiety above the median. However, the interaction term was non-statistically significant in each ANOVA model tested; there is no effect on: expectations of mathematics achievement ($F(1,189)=0.027$, $p=0.87$); expectations of general academic achievement ($F(1,189)= 1.403$, $p=0. 238$); need for academic support ($F(1,188)= 0.315$, $p=0 .57$); or need for special education ($F(1,189)= 0.127$, $p=0 .72$) (Table 4). These findings allow us to broaden our knowledge about the interplay of stereotypes and anxiety in mathematics education. Previous research has shown that elementary school teachers with low math-self-concept tend to endorse math-gender stereotypes (Relich, 1996) and that the effects of teacher's mathematics anxiety on student performance might be mediated by the student's endorsement of math-gender stereotypes (Beilock et al. 2010). Our findings suggest that when pre-service elementary teachers form expectations about students, gender stereotypes and mathematics anxiety operate as strictly

independent factors.

-- Table 4 --

5. Discussion and Conclusions

The available evidence allows us to conclude that mathematics anxiety should be considered a pressing issue in teacher education. It is a phenomenon that affects children from a very young age (Ramírez et al. 2013) and carries significant consequences for their learning of mathematics (Ma, 1999) and career choices (Scarpello, 2005); moreover, it is deeply embedded in the teaching community. Education majors, and especially elementary school education majors, are more likely to present mathematics anxiety than students from other fields (Baloglu & Koçak, 2006; Bessant, 1995; Hembree, 1990) and mathematics anxious pre-service elementary school teachers show less self-teaching efficacy in mathematics (Bursal and Paznokas, 2006; Swars et al. 2006; Gresham, 2008). Nonetheless, this might be just the tip of the iceberg, as we have yet to uncover the multiples ways in which mathematics anxiety may affect teaching. The purpose of this study has been to contribute to the understanding of this issue by exploring how mathematics anxiety influences the pre-service elementary school teachers' expectations and belief about their students, and how mathematics anxiety relates to gender stereotypes commonly held in the domain of mathematics.

Our results confirmed that indeed, mathematics anxiety can negatively influence the expectations pre-service elementary school teachers have about their students. We presented to pre-service elementary school teachers descriptions of students facing difficulties at school with mathematics lessons, and asked them to evaluate those cases. We found that pre-service elementary school teachers with mathematics anxiety above the median assign statistically significantly lower expectations of future mathematics achievement to the students than their below the median counterparts. We also find that participants assign lower expectations of future mathematics achievement to girls than boys, confirming the presence of a gender stereotype threat. The two effects, however, appear to be strictly independent as we did not find statistically significant interaction effects between the pre-service elementary school teacher's mathematics anxiety and the biases associated with student's gender. If this effect takes place in real classroom settings once pre-service elementary school teachers start teaching, children could be affected by those negative expectations and in turn develop negative self-concepts about mathematics (Kuklinsky & Weinstein, 2001). Our results also suggest that mathematics anxiety could affect a teacher's capacity to develop inclusive education environments in their classrooms. We found that pre-service elementary school teachers above the median on mathematics anxiety are more likely to recommend special education for students facing difficulties in mathematics.

Another relevant finding was that pre-service elementary school teachers tend to extrapolate current underachievement in mathematics to general academic achievement problems only for female students. This result contributes to the existing evidence of gendered stereotypes in

mathematics, as we found no such effect in an alternative setup that featured hypothetical cases that presented problems in language lessons.

Our research design has some limitations to extend our results to school settings, thus, we cannot determine whether these biased decisions are still present once pre-service elementary school teachers begin their professional career. Cady et al. (2006) used a longitudinal study to analyze the transition from pre-service to in-service teachers and found that beliefs about the teaching and learning of mathematics tend to change. Thus, we cannot directly assume our results will hold for in-service teachers. Therefore, further research on mathematics anxiety and expectations should focus on practicing teachers, while new research on pre-service elementary school teachers should contribute to our understanding of mathematics anxiety as a complex phenomenon, exploring new implications and developing effective strategies to diminish mathematics anxiety during teacher education. To our knowledge, this is an unsolved drawback of current teacher education curriculum in Chile. A content analysis of the syllabus of elementary school teachers' education courses -which included eleven Chilean universities- showed that mathematics anxiety was completely absent in pre-service elementary school teachers' education programs (Varas et al., 2008).

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TABLES

Table 1. Number of participants per experimental condition

Student		Pre-service teacher Math anxiety	
Gender	SES	Low	High
Male	Low-SES	31	19
Male	High-SES	28	20
Female	Low-SES	20	25
Female	High-SES	22	29

Table 2. Correlations of mathematics anxiety, performance and self-efficacy

Variable	Mathematics performance	Mathematics self-efficacy
Mathematics anxiety	-0.104	-0.196**
Mathematics performance		0.345**

** Statistically significant at 1%.

Table 3. Pre-service teachers' expectations and beliefs according to pre-service teacher's math anxiety, student's gender and socioeconomic status

	(Mean ± Standard Deviation)					
	Pre-service teacher		Student			
	Math anxiety		Gender		SES	
	Low	High	Male	Female	Low	High
Expectations of math achievement (a)	4.38 ± 0.73	4.01 ± 0.85	4.4 ± 0.71	3.99 ± 0.86	4.18 ± 0.83	4.22 ± 0.79
(F test)	F(1,189)= 7.7**		F(1, 189)= 10.4**		F(1, 189)= 0.33	
Expectations of general achievement (b)	4.21 ± 0.82	3.98 ± 0.81	4.24 ± 0.78	3.96 ± 0.84	3.98 ± 0.82	4.22 ± 0.81
(F test)	F(1, 189)= 2.8		F(1, 189)= 5.0*		F(1, 189)= 5.2*	
Need for academic support (c)	3.86 ± 0.72	3.74 ± 0.76	3.88 ± 0.62	3.72 ± 0.84	3.93 ± 0.66	3.68 ± 0.79
(F test)	F(1, 188)= 0.58		F(1, 188)= 1.62		F(1, 188)= 5.21*	
Need for special education (d)	1.36 ± 0.57	1.68 ± 0.83	1.43 ± 0.62	1.6 ± 0.81	1.56 ± 0.72	1.47 ± 0.73
(F test)	F(1, 189)= 8.39**		F(1, 189)= 1.44		F(1, 189)= 1.03	

* statistically significant at 5%.

** statistically significant at 1%.

(a) Expectations of math achievement: The scale ranges from 1 to 5, where higher scores represent an attribution of higher expectations.

(b) Expectations of general achievement: The scale ranges from 1 to 5, where higher scores represent an attribution of higher expectations.

(c) Need for academic support: The scale ranges from 1 to 5, where higher scores represent an attribution of higher need for this support strategy.

(d) Need for special education: The scale ranges from 1 to 5, where higher scores represent an attribution of higher need for this support strategy.

Table 4. ANOVA Model. Expectations about hypothetical students with difficulties in mathematics

Model (dependent variable)	Source of variation	Sum of squares	df	F-ratio	partial eta squared (a)
1 Expectation of future mathematics achievement	Constant	3,302.766	1	5,521.726 **	0.967
	Mathematics anxiety	4.607	1	7.703 **	0.039
	Student's gender	6.23	1	10.415 **	0.052
	Student's SES	0.195	1	0.326	0.002
	Mathematics anxiety x student's gender	0.016	1	0.027	0
	Error	113.048	189		
2 Expectation of general academic achievement	Constant	3,140.368	1	4,940.362 **	0.963
	Mathematics anxiety	1.772	1	2.787	0.015
	Student's gender	3.182	1	5.005 *	0.026
	Student's SES	3.322	1	5.227 *	0.027
	Mathematics anxiety x student's gender	0.892	1	1.403	0.007
	Error	120.139	189		
3 Need for academic support	Constant	2,708.449	1	5,087.735 **	0.964
	Mathematics anxiety	0.311	1	0.584	0.003
	Student's gender	0.862	1	1.62	0.009
	Student's SES	2.778	1	5.218 *	0.027
	Mathematics anxiety x student's gender	0.168	1	0.315	0.002
	Error	100.082	188		
4 Need for special education	Constant	437.241	1	873.489 **	0.822
	Mathematics anxiety	4.201	1	8.393 **	0.043
	Student's gender	0.724	1	1.446	0.008
	Student's SES	0.516	1	1.032	0.005
	Mathematics anxiety x student's gender	0.064	1	0.127	0.001
	Error	94.608	189		

* Statistically significant at 5%.

** Statistically significant at 1%.

(a) Partial eta square is a measure of the size of the effect that ranges between 0 and 1.

APPENDIX

Sample description paragraph

("John" / "Johanna") is a student in a ("public" / "private") school located in ("Pudahuel"/"Las Condes"). ("He" / "She") lives with both parents and is the middle child in the family. ("His" / "her") mother is a ("physician" / "domestic worker") and his father is ("an attorney" / "currently unemployed"). ("He" / "She") has an average IQ but is earning poor grades in math. ("He" / "She") has not been turning in ("his" / "her") homework in several subjects and does not use his time efficiently in class. ("John" / "Johanna") used to have a positive attitude about school, earned good grades, and was well liked by ("his" / "her") teachers. Recently, ("he" / "she") has become withdrawn and has begun to receive a number of behavioral referrals. For example ("he"/"she") has become aggressive with ("his" / "her") peers by getting into both verbal and physical fights at least once a week. ("His" / "Her") parents have met with the teacher and school counselor on a few occasions, but the situation has not improved.

Table A1. Pre-service teachers' expectations and beliefs according to pre-service teacher's math anxiety, student's gender and socioeconomic status about hypothetical students with difficulties in language

	(Mean ± Standard Deviation)					
	Pre-service teacher		Student			
	Math anxiety		Gender		SES	
	Low	High	Male	Female	Low	High
Expectations of language achievement (a)	3.91 ± 0.99	4.01 ± 0.93	4.0 ± 1.0	3.92 ± 0.91	3.92 ± 0.95	4.0 ± 0.97
(F test)	F(1, 192) = 0.505		F(1, 192) = 0.390		F(1, 192) = 0.242	
Expectations of general achievement (b)	4.01 ± 0.84	4.16 ± 0.85	4.09 ± 0.88	4.07 ± 0.82	3.89 ± 0.88	4.27 ± 0.77
(F test)	F(1, 192) = 0.792		F(1, 192) = 0.032		F(1, 192) = 9.767**	

* statistically significant at 5%.

** statistically significant at 1%.

(a) Expectations of language achievement: The scale ranges from 1 to 5, where higher scores represent an attribution of higher expectations.

(b) Expectations of general achievement: The scale ranges from 1 to 5, where higher scores represent an attribution of higher expectations.