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How teachers' mathematics anxiety affects their students' mathematics anxiety and mathematics confidence

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Past research has well-documented strong affective reactions towards mathematics from both teachers and students which is often attributed to mathematics anxiety. Elevated levels of mathematics anxiety are frequently linked to poor achievement in mathematics, and decreased confidence and motivation for both students and teachers. This paper reports the results of a large sample study which explored the interrelationship between teachers' and their students' mathematics anxiety. Participants included 1545 students aged 11–14 and 26 secondary school mathematics teachers. The findings show that mathematics anxiety remains of concern for both teachers and students, and that teachers' anxiety influences the mathematics anxiety of their students. Substantial gender stereotypes were also identified in the study. These point to the need for an improved understanding of mathematics anxiety as this holds implications for all involved in mathematics education.

Keywords: Mathematics anxiety, mathematics education, mathematics teachers, teacher student relationship, affective education.

Introduction

Past research (e.g., Dowker et al., 2016) has shown that both students and teachers have strong affective reactions like worry towards mathematics inside and outside the mathematics classroom. This domain-specific response is often attributed to mathematics anxiety; a negative emotional reaction towards mathematics that can be described as “feelings of tension, apprehension, or fear that interfere with mathematical performance” (Richardson & Suinn, 1972, p. 551). Mathematics anxiety includes a variety of contextualised components from academic like test/evaluation anxiety and class anxiety (Richardson & Suinn, 1972) to everyday situations, such as working out a budget, all of which have been shown to cause emotional, psychological, and even physical pain (Lyons & Beilock, 2012). Pekrun (2006) proposed control-value theory as a method to analyse the critical antecedents and potential effects of an achievement emotion – like mathematics anxiety. Control-value theory proposes that individuals' positive and negative emotional experiences in achievement situations, results from their appraisals and interpretations of the achievement activities and their outcomes. The consistency of findings on the effect of mathematics anxiety on the individual spans across countries (Lau et al., 2022) making mathematics anxiety a "global phenomenon" (Foley et al., 2017, p. 52) and highlighting the universality of the adverse effects of mathematics anxiety on different areas including achievement (e.g., Barroso et al., 2021).

In some of the earliest research into mathematics anxiety (e.g., Richardson & Suinn, 1972), mathematics anxiety and its understanding have been treated as unidimensional. More recently, however, it has been argued that mathematics anxiety is a multidimensional construct comprising several elements. For example, gender gaps in mathematics performance are well documented in

OECD countries, the European Union (EU) and the UK (OECD, 2019) with gender differences in mathematics anxiety also falling along gender lines (e.g., Devine et al., 2012; Hill et al., 2016).

Cognitive elements and social influences also play a role in the onset of mathematics anxiety (e.g., Dowker et al., 2016). Research into mathematics anxiety among teachers and pre-service teachers has identified high levels of mathematics anxiety and anxiety about teaching mathematics with significant gender differences in the former but not the latter (e.g., Hadley & Dorward, 2011). This mathematics anxiety can be imparted to students as previous studies show and the transmission also falls along gender lines (e.g., Dowker et al., 2016).

Methods

Previous studies examining mathematics anxiety of students and teachers consider them entirely separate. The purpose of the present study was to explore the different components of students' and teachers' mathematics anxiety, their interrelationship, and the effect of any relationship onto a students' mathematics anxiety and mathematics confidence.

Participants

Participation was voluntary and the project was approved by the relevant ethics committee of the institution the research was conducted in. School headteachers were contacted to seek expressions of interest, interested schools contacted parents to notify them about the project and to allow for non-participation/opt-out. Three schools took part in the project and in total 1545 students, from 70 different classes participated. The demographic data is presented in Table 1.

Table 1: Student Demographics

Students	School A		School B		School C	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Gender						
Male	339	53.30 %	266	46.75 %	165	48.53 %
Female	285	44.81 %	286	50.26 %	167	49.12 %
Non-Binary [†]	12	1.89 %	17	2.99 %	8	2.35 %
Age						
Year 7	219	34.43 %	187	32.86 %	109	32.06 %
Year 8	198	31.13 %	211	37.08 %	106	31.18 %
Year 9	219	34.43 %	171	30.05 %	125	36.76 %

[†]Non-Binary indicates any student that responded neither male nor female.

Research Questions

This project explores various components of mathematics anxiety in students and teachers to identify any differences between groups and interrelationship between components of mathematics anxiety in teachers and students and students' mathematics confidence. The research questions guiding this exploration are:

- 1) What individual differences, such as gender and age, exist within mathematics anxiety and mathematics confidence of secondary students?
- 2) How does the mathematics anxiety of a teacher affect the mathematics anxiety and mathematics confidence of their students?

Instruments

During normal mathematics lessons, participants (students and teachers) were provided with a paper questionnaire comprising two validated measures. These measures were chosen with respect to their suitability to the participants, given their age and maturity. The completion time was also an important factor in determining which instruments should be used, given this research occurred during the school day. Mathematics anxiety in students was measured using the Modified Abbreviated Math Anxiety Scale (mAMAS; Carey et al., 2017). The scale comprises nine 5-point Likert statements concerning situations involving mathematics in a range of settings. This is a two-factor comprising learning *mathematics anxiety* and *evaluation mathematics anxiety*. Participants to indicate how anxious they would feel in these statements from 1 = "Low Anxiety" to 5 = "High Anxiety".

Mathematics confidence in students was measured using an adapted version of the Mathematics Confidence Scale (MSC; Hendy et al., 2014). Utilising Carey et al.'s (2017) approach, small alterations to items were made to naturalise the language to British students, such as "math" to "maths". For each statement participants are required to respond by indicating their agreement on a symmetrical 5-point Likert-type scale. Responses were reverse coded with higher scores indicating higher confidence.

Mathematics anxiety in teachers was measured using the Math Anxiety Scale for Teachers (MAST; Ganley et al., 2019). The scale comprises nineteen 5-point Likert-scale statements concerning situations the use of mathematics, inside and outside of the classroom, and can be subdivided into four subscales, measuring Emotionality, Worry, Social/Evaluative and Anxiety About Teaching Maths. Teacher's mathematics anxiety was also measured using the Mathematics Teaching Anxiety Scale (MTAS; Hunt & Sari, 2019). The scale focuses on the anxiety associated to the teaching of mathematics and prioritizes pedagogical components, an associated but distinct to the above MAST measure.

Results

The results are first presented here by students' gender and year and in terms of differences in mathematics anxiety and mathematics confidence. Next, the mathematics anxiety of teachers and mathematics teaching anxiety by gender is presented. Finally, backward regressions are conducted to examine if any elements of teachers' anxiety impact the mathematics anxiety or confidence of their students.

Gender Differences

In terms of mathematics anxiety, it was observed that boys consistently reported significantly lower levels of overall mathematics anxiety, evaluation mathematics anxiety, and learning mathematics anxiety, whereas they reported significantly higher levels of mathematics confidence compared to girls. Notably, mathematics anxiety peaked when connected to the evaluation anxiety items, particularly when contemplating and completing a mathematics test or when confronting upcoming mathematics homework with a looming deadline. Mathematics anxiety was lowest when connected to listening to other students or watching their teaching solve mathematics questions.

Table 2: Gender differences of students' mathematics anxiety and mathematics confidence

	Males		Females		<i>t</i> (1506)	<i>p</i>	<i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Overall MA	2.09	0.78	2.45	0.76	9.06	< .001***	0.47
Evaluation MA	2.72	1.04	3.30	0.99	11.19	< .001***	0.58
Learning MA	1.60	0.73	1.77	0.73	4.71	< .001***	0.24
Mathematics Confidence	3.46	0.82	3.02	0.76	10.67 [†]	< .001***	0.55

[†]df = 1504; MA = Mathematics Anxiety, Cohen's *d* effect sizes. **p* < .05. ***p* < .01. ****p* < .001

Year Differences

Table 3: Year differences in students' mathematics anxiety and mathematics confidence

	Year 7		Year 8		Year 9		<i>F</i>	<i>p</i>	η^2
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Overall MA	2.46	0.84	2.22	0.78	2.18	0.78	18.22	< .001***	.023
Evaluation MA	3.19	1.07	2.93	1.06	2.93	1.05	10.78	< .001***	.014
Learning MA	1.87	0.83	1.65	0.72	1.59	0.68	20.31	< .001***	.026
Mathematics Confidence	3.26	0.85	3.20	0.83	3.23	0.80	0.69	.501	.001

Students are aged by school years, Year 7 (aged 11–12), Year 8 (aged 12–13), and Year 9 (aged 13–14), MA = Mathematics Anxiety. **p* < .05. ***p* < .01. ****p* < .001

Mathematics confidence was not significantly different between school years; however, all three components of mathematics anxiety were significantly different with mathematics anxiety decreasing between years, with Year 7 students (aged 11–12) being consistently more anxious than Year 8 students (aged 12–13) and Year 9 students (aged 13–14). Inter-year differences were significant throughout (*p* < .001). Experiences differences were also considered however, they were not statistically significant (*p* > .3).

Teachers

Table 4: Gender differences in teachers' mathematics anxiety and mathematics teaching anxiety

	Males (<i>N</i> = 12)		Female (<i>N</i> = 14)		<i>U</i>	<i>Z</i>	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
MTAS	1.99	0.45	2.12	0.39	73	-0.57	.595
MAST_AATM	1.70	0.72	2.32	0.83	44	-2.06	.041*
MAST_Emotionality	1.17	0.31	1.45	0.73	70	-0.82	.494
MAST_Social	1.78	0.81	2.48	0.84	44	-2.08	0.41*
MAST_Worry	1.35	0.46	1.91	0.96	51	-1.74	0.95

p* < .05. *p* < .01. ****p* < .001

Teacher-Student Effect

To explore the direct effect of the teacher-student effect, four backwards regressions were conducted. The results are shown in Table 5. Overall mathematics anxiety in students is impacted by their teacher's gender and years of teaching experience. Students with male teachers reported lower levels of mathematics anxiety than students with female, and the more teaching experience a teacher has, the lower the mathematics of their students.

Evaluation-based mathematics anxiety in students is impacted by their teachers' social-based mathematics anxiety and non-significantly by their worry-based mathematics anxiety. Whereby, students whose teachers reported higher levels of social-based mathematics anxiety themselves reported higher levels of evaluation anxiety. Learning-based mathematics anxiety in students is impacted by a teacher's gender, experience, and worry-based mathematics anxiety. Mathematics confidence in students is impacted by a teacher's gender, experience, emotion-based mathematics anxiety, social-based mathematics anxiety, and non-significantly by their worry-based mathematics anxiety.

This suggests that a teacher's gender impacts their students' mathematics anxiety and mathematics confidence. Additionally, a teacher's mathematics anxiety impacts their students' mathematics anxiety and mathematics confidence. Interestingly, the teacher's mathematics teaching anxiety, which specifically considers how nervous or worried they feel about teaching mathematics, does not appear to directly affect their students, only the anxiety of their own mathematics has a significant impact. For the evaluation and confidence regression models the component worry mathematics anxiety remained in the model even though it was non-significant (*p* > .05) as removing the component decreased the accuracy of the regression model.

Some of the items in the social-based mathematics anxiety measure includes elements about a teacher's response to being evaluated. This shows an interesting connection to the students' evaluation anxiety where teachers who are anxious about themselves being evaluated transfer this anxiety to their students who go on to feel anxious when their mathematics is being evaluated.

Table 5: Regression Coefficients

	β	<i>SE</i>	<i>t</i>	<i>sig</i>
Overall				
Mathematics Anxiety				
(Constant)	2.49	0.11	22.06	< .001***
Gender	-0.12	0.04	-2.70	.007**
Experience	0.01	0.00	2.17	.030*
Evaluation				
Mathematics Anxiety				
(Constant)	2.86	0.08	34.84	.001***
MAST_Social	0.17	0.05	3.09	.002**
MAST_Worry	-0.12	0.06	-1.89	.059
Learning				
Mathematics Anxiety				
(Constant)	1.72	0.13	13.29	.001***
Gender	-0.09	0.04	-2.02	.043*
Experience	0.01	0.00	2.47	.014*
MAST_Worry	0.06	0.03	2.04	.042*
Mathematics Confidence				
(Constant)	2.46	0.16	15	< .001***
Gender	0.12	0.05	2.44	.015*
Experience	-0.01	0.00	-3.46	.001**
MAST_Emotionality	-0.32	0.10	-3.21	.001**
MAST_Social	-0.11	0.05	-2.26	.024*
MAST_Worry	0.17	0.09	1.92	.055

Backwards Regressions using Teachers' MTAS, MTAS_AATM, MAST_Emotionality, MAST_Social, MAST_Worry, Experience and Gender (1 = Female, 2 = Male) as input parameters.

* $p < .05$. ** $p < .01$. *** $p < .001$

Conclusion

The analysis shows significant gender differences both for students and teachers. Female students reported higher levels of mathematics anxiety and lower levels of mathematics confidence than male students, consistent with previous literature (e.g., Carey et al., 2017; Devine et al., 2012; Dowker et al., 2016).

Gender differences were also identified in teachers' levels of mathematics anxiety. Female teachers reported higher levels of mathematics anxiety for all five components of mathematics anxiety however, only two differences were considered statistically significant, namely anxiety about teaching mathematics and social/evaluative anxiety, which contrasts with earlier studies of pre-service teachers (e.g., Hadley & Dorward, 2011). Teaching mathematics and social/evaluative anxieties refer to mathematics mistakes, feeling under pressure in lessons and using or explaining advanced mathematics strategies that are more related to evaluative components of mathematics and mathematics teaching.

Regression analysis showed that a teacher's gender, along with their mathematics anxiety expressed through their worry and evaluative components, significantly affect their students' mathematics anxiety and mathematics confidence confirming previous research findings (Dowker et al., 2016). The study further indicated that the more nervous teachers feel when they think their mathematics ability is being evaluated, the more anxious their students being evaluated feel. This implies that nervousness or anxiety towards the evaluative components of mathematics is directly imparted from teacher to student. Equally, the more worried, overwhelmed or panicked a teacher feels in response to mathematics, the more anxious their students feel in mathematics learning situations in general, like classroom lessons. This is further suggesting that mathematics anxiety on an intrinsic level is also transmissive onto students and impacts their learning.

Addressing a teacher's mathematics anxiety, particularly their anxieties towards being evaluated in a mathematics classroom, could reduce their students' mathematics anxiety. Furthermore, as an individual's mathematics anxiety is significantly associated with their mathematics achievement (Barroso et al., 2021), reducing a teacher's mathematics anxiety may directly reduce a students' mathematics anxiety and thus improve their academic achievement.

The findings also suggest that mathematics anxiety decreases with age as reported levels of mathematics anxiety, both as an overall construct and individual components, were lower for year 9s than year 7s who were the highest. Nevertheless, as the students in this study are from three distinct cohorts the reduction in mathematics anxiety may be due to other factors. Longitudinal panel-design studies would be required to further examine if mathematics anxiety decreases because of student maturation. We are continuing with further research to explore these with a larger study sample and further examine the relationships from these preliminary findings.

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