Math Anxiety in The Virtual Classroom During Covid-19 Pandemic and its Relationship to Academic Achievement

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Abstract: The plethora of research studies on the impact of the COVID-19 pandemic on education gives us a first picture of the difficulties and challenges encountered at the various educational levels, especially at the elementary level, by students aged from 6 to 12 years old. The aim was to examine the existence of math anxiety in primary education and how math anxiety differentiates performance according to gender during the COVID-19 confinement. A quantitative empirical research carried out, using a fifteen-question questionnaire, with a 5-point Likert scale, which employed the Mathematics Anxiety Rating Scale (MARS), the Mathematics Anxiety Scale (MAS), the Abbreviated Math Anxiety Scale (AMAS) and a math test. The sample consisted of 173 Greek sixth grade students. The questionnaire and the math test were provided to the students by the teachers at the beginning of the school year in September 2021. Sixth graders, especially girl students, get quite anxious when involved with math learning activities. Math anxiety affected more girl than boy students' grades in the math test. Math anxiety affected primary 11 to 12-year-old students, while girl students exhibited higher math anxiety than their counterparts. In addition, math anxiety affected girls' performance in the math test.

Keywords: Elementary school; Online Learning; Gender; Math Anxiety; Achievement

INTRODUCTION

One issue we need to clarify from the start is the differences between distance education and emergency digital education implemented during the pandemic. Distance education is an alternative and flexible learning option for learners, an interdisciplinary field that has evolved over time and is characterized by the spatial distance that separates instructors from learners, the use of specialized digital resources and tools designed to respond to particular learning needs and guidance through open educational practices (Bozkurt et al., 2019; Zawacki-Richter et al., 2020). In contrast, emergency online digital education was formed without long-term planning in a short period of time. It was a necessity for educational systems to respond to the special conditions of the total ban on mobility that prevailed around the world and the general shift to teleworking and social distancing. It was therefore an obligation, a temporary educational solution that tried to respond to existing problems that forced educational communities to temporarily adopt different strategies and set different priorities in the educational process (Bozkurt & Sharma, 2020).

The rich literature that has developed at a rapid pace around the question of the effects of the crisis on education gives us a first picture of the difficulties and challenges that the various educational systems encountered as well as of the ways and innovations that they developed to adapt to the new conditions (Bao, 2020; Flores & Gago, 2020; Moorhouse, 2020).

Greece, like most countries, announced emergency remote teaching at all levels of education in March 2020 (UNESCO, 2020). In a short period of time, the educational units were called on to adapt to the urgent and unpredictable condition of the spread of the pandemic due to the COVID-19 disease by taking the necessary measures to limit movement from place to place, gatherings and communication. In order to continue in safe conditions, the educational units were asked to interrupt the learning process requiring physical presence in the classrooms and to adapt to the emergency distance education model (Crompton et al., 2021).

The literature review clearly shows that the consequences of the pandemic were more severe on children (Fore, 2020; Lee, 2020; Liu et al., 2020). School closures had serious psychosocial effects on children (Spinelli et al., 2020). Children, showed high levels of anxiety and insecurity, as they had great difficulty understanding what was happening (Shapiro et al., 2020).

The long period of online learning and the substantial interruption of all those factors present in live teaching raises concerns about the effects on the cognitive development, the motivation to learn and the learning progress of children. It was imperative that the school developed a comprehensive plan to address the potential learning and mental health needs of children (Ghosh et al., 2020; Phelps & Sperry, 2020).

ICT integration in the modern classroom has already been advocated by the OECD (2001) and used in different situations (Crompton et al., 2021). However, until the onset of the COVID-19 pandemic, the majority of European educational systems had not altered their primary method of instruction—that is, teaching in classrooms (Schleicher, 2020).

While the coronavirus pandemic brought digital learning into educational institutions, the vast majority of schools and teachers was caught unprepared and struggled to adapt to the new teaching framework (Hodges et al., 2020), 'victimizing' certain groups of students, such as females.

According to a flurry of new studies (e.g., Patrinos et al., 2022; Werner & Woessmann, 2023), the COVID-19 pandemic was an obstacle that hindered students' learning. For example, Di Pietro's (2023) meta-analysis**,** with a view to investigating the impact of COVID-19 on student achievement—239 estimations from 39 studies spanning 19 nations were included in the collection—found that the learning results were generally negatively impacted by the COVID-19 pandemic, i.e., students have fallen behind in math and science compared to other subjects, while students are still recuperating from the initial learning losses at least one year following COVID-

19; thus, new studies are needed because findings from new studies will show the level of the impact of school closure during the pandemic on students' learning and on education in general.

According to the World Economic Forum (2022), the full effects of the COVID-19 pandemic are just now beginning to become apparent, thus future effects on students' competencies, abilities, knowledge (Hanushek & Woessmann, 2020), and the psychological aspects of learning should be taken into consideration.

Determining whether and to what extent the interruption of face-to-face instruction resulted in student learning deficits is crucial for this reason. In order to help students recover from the learning deficit brought on by the closure of schools during the COVID-19 pandemic, educators and decision-makers in the field of education must first identify the categories of students who may require additional support (Di Pietro, 2023).

Since a part of empirical studies points out gender differences in e-learning (Devine et al., 2012; Drabowicz, 2014; Wongwatkit et al., 2020; Khasawneh et al., 2021; Bertoletti et al., 2023) it is censorious to investigate, among other factors, MA gender differences and performance in digital environments, because one of the main driving factors interpreting this gender gap is the students' anxiety during the COVID-19 school closure (Bertoletti et al., 2023). Meanwhile, to date few studies have explored specific gender differences in online-learning math activities (Aguillon et al., 2020), e.g. math anxiety. Therefore, the overall objective of the research is to determine the level of math anxiety and in what way it affected sixth graders' math performance during the school closure in the COVID-19 pandemic.

The three specific pointed objectives are:

- To confirm the existence of math anxiety in sixth graders
- To determine whether math anxiety differs in gender
- To assess performance in relation to math anxiety during the COVID-19 lockdown period.

Finally, the main research question addressed by the research is how math anxiety affects the performance of sixth-grade students in mathematics during the COVID-19 pandemic, followed by a second one exploring the existence of math anxiety among sixth graders.

LITERATURE

Math anxiety

While some difficulties with mathematics can be linked to a lack of understanding of the material, other difficulties can be brought on by emotional issues. The term MA refers to the adverse emotional response that is triggered when someone meets a mathematical task, according to Cipora et al. (2015). MA, which is defined as a negative emotional reaction to mathematics, may affect a person's ability to accomplish mathematical assignments. Furthermore, MA makes students feel less confident about their mathematical skills and keeps them from generally relishing their journey into the "mathland."

To help understand when the state of MA is triggered, the 'Growth Zone Model' of Johnston-Wilder et al. (2013) was deployed. As shown in Fig. 1, there are three zones when the student tackles a mathematical situation: the Comfort zone, where the students feels confident; the Growth zone, where the students experiences learning; the Anxiety zone, where the students begins to expose themselves to math anxiety.

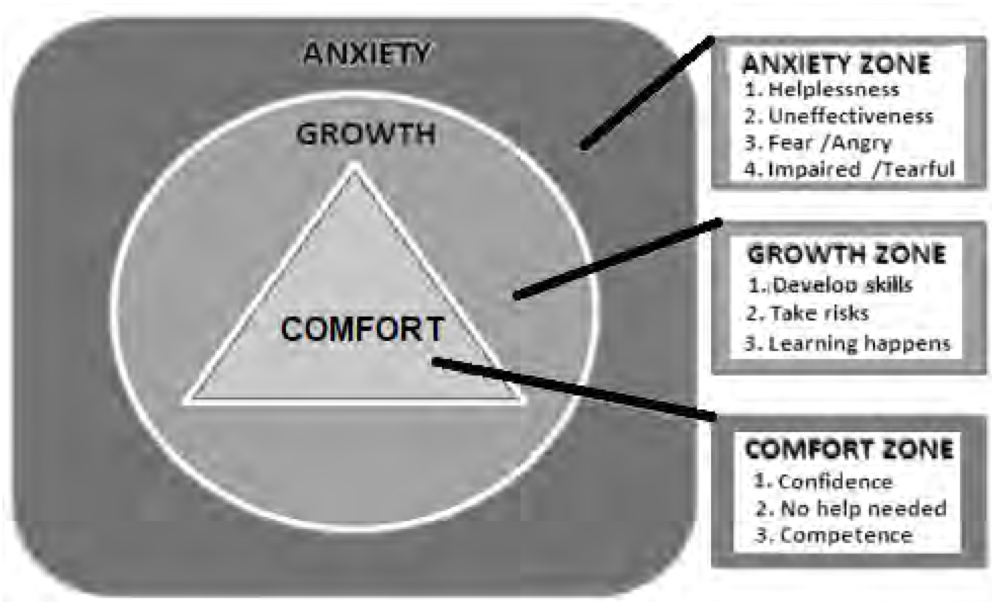

Figure 1: Growth Zone Model

MA is a condition which can cause several symptoms, including emotional -for instance, feelings of apprehension, aversion, tension, distress, irritation or fear-, physical -for instance, butterflies, tachycardia, struggling to catch your breath-, or behavioral -for instance, not acting properly in class, avoiding math assignments and studying (Hembree, 1990). Young school children are reported to exhibit math anxiety from approximately the age of six (Krinzinger et al., 2009; Beilock et al., 2010; Vukovic et al., 2013). As Dowker et al. (2016) mentioned, negative attitudes towards mathematics usually increase at the age of secondary school and remain during post-secondary education and throughout adulthood. It is hard to determine how often math anxiety occurs, because measurements of math anxiety are continuous and there is no clear limit regarding whether an individual is math-anxious or not (Devine et al., 2018).

Math anxiety has an impact on individual wellbeing – e.g., some students will face their math lessons with fear or skip their math homework due to a dislike of experiencing negative emotions (Dowker et al., 2016). Additionally, intellectual factors may be associated with MA. Although there is increasing evidence that children demonstrate MA as early as first grade (Ramirez et al., 2013), little is known about the change of MA across childhood. Few studies showed that the level of MA increases with age (Dowker et al., 2012; Krinzinger et al., 2009).

Children with developmental dyscalculia (a specific deficit in the acquisition of mathematics skills) and other learning disabilities in mathematics are more likely to have MA (Rubinsten & Tannock 2010; Passolunghi, 2011). Furthermore, MA may be influenced by an individual's other personal characteristics. For instance:

- Gender - girls are more likely to experience anxiety about math (Bieg et al., 2015);
- Self-esteem - a lower self-esteem leads to higher levels of math anxiety (Abbasi et al., 2013);
- Instruction and learning style – students who had more negative experiences with instructional methods had higher levels of MA compared to those who had fewer negative experiences (O'Leary et al., 2017), and
- Attitude towards math – those who generally like math usually appear to have lower math anxiety levels than those who dislike it (Kargar et al., 2010).

Math anxiety and Gender differences

Studies regarding adult populations have revealed females to have higher MA than males (Ferguson et al., 2015; Van Mier et al., 2019).

Girls showed greater anxiety than boys in the majority of the PISA participating nations (OECD, 2013). In addition, experts are increasingly of the opinion that MA develops in childhood (Vukovic et al., 2013). Studies examining gender-related MA in elementary education during the COVID-19 pandemic are few, nevertheless. Although some studies found no gender differences, other research has found that there exists a MA gender difference among students in elementary schools (Griggs et al., 2013). However, recent research by Puteh and Khalin (2016) found no differences in MA levels between male and female students. Yet, it is ambiguous if boy or girl primary school students experience different levels of MA (Hill et al., 2016).

Collectively, although previous reports on MA differences between genders have been based upon results obtained from secondary school samples, MA differences are likely to develop during primary school years or even earlier (Hill et al., 2016). For example, in the study of Mitchell and George (2022), the mathematics anxiety score for males was lower than that of female sixth grade students.

Ayuso et al. (2020) mentioned more negative feelings for girls than boys during primary education years in math classes, which was later confirmed by the research of Arnal-Palacián et al. (2022). Thus, according to Ayuso et al. (2020) during the teaching of mathematics in primary education, girls experience less positive emotions, which is in the same line as the conclusions of Hembree (1990). On the other hand, Sorvo et al. (2017) found no gender differences in second to fifth-grade students in Finland at the beginning of the school year and stated that math anxiety appears later in the school year in some situations during the lesson, as in question-and-answer exercises, where the researchers found that it was higher among girls than boys.

Effective learning of mathematics at in primary education is often a challenging situation for most school-aged children. The research of Mata et al. (2022) suggested that primary education students' emotions are complex and it is important to understand them to improve math learning outcomes.

Math anxiety and performance

Around seventy years ago research by Dreger and Aiken (1957) revealed mathematics anxiety and since then it still seems to majorly affect students' performance (Siaw et al., 2021). By common confession, MA is described as a predominantly negative emotion, which, in the literature, has been linked to a multitude of reactions. Cemen (1987) reports that students with math anxiety were so overwhelmed by negative emotions that they could not assimilate mathematical concepts, no matter how well someone explained them.

Since then, a plethora of studies have pointed out math anxiety as a significant criterion of learning mathematics and of low students' test-scores, for both standard and custom assessments, with an impact on school grades (e.g. Núñez-Peña et al., 2013; Foley et al., 2017; Zhang et al., 2019; Siaw et al., 2021) and performance (Gunderson et al., 2018; Yuan et al., 2023). For example, in their research on the effects of math anxiety on student achievement, Nunez-Pena et al. (2013) concluded that math anxiety is the most critical factor explaining low test scores of students at university.

Math anxiety is an important cause of math difficulties, as students who are highly apprehensive about math tend to fail math-related activities more often than students who do not experience such anxiety (Caviola et al., 2017). In addition, negative thoughts are evoked in the person, as they believe they may fail, and they are essentially confused when dealing with the negative thoughts and solving a math problem at the same time (Ashcraft & Kirk, 2001). Although moderate levels of stress can help to enhance motivation, excessive stress can become detrimental (Wang et al., 2015).

Moreover, a recent meta-analysis of 49 studies (Zhang et al., 2019) suggested a powerful negative link between math anxiety and performance, especially among older high school students. In addition, they found a more solid correlation between math anxiety and performance amid students from Asia than amid students from Europe or America. A cross-national study of Yuan et al. (2023) used a sample group of 17,284 fifteen-year-old students from the PISA-2012 database, regarding mathematics performance and MA, which firmly established negative effects of math anxiety in math performance in either lower or higher math achievement countries.

However, in reference to primary school children, the relationship between MA and mathematics performance remains unclear. Findings from previous studies are contradictory, with some studies suggesting that primary school students' MA is unrelated to achievement (e.g. Dowker et al., 2012; Haase et al., 2012). In particular, in their research, Dowker et al. (2012) studied the relationship between mathematics achievement, mathematics anxiety, unhappiness due to low achievement, willingness to engage in mathematics and self-assessment concerning primary school students studying in the third grade (ages 7-8) and in the fifth grade (ages 9-10). The students were asked to solve exercises that required numeracy skills, as well as to complete a questionnaire on attitude and anxiety towards mathematics. The results of the research showed that MA was not related to performance, in contrast to self-assessment, which showed a significant correlation. Meanwhile, other scholars suggested the existence of a negative correlation with mathematical performance at this age (e.g. Harari et al., 2013; Jameson, 2013; Vukovic et al., 2013; Wu et al., 2014; Villavicencio & Bernardo, 2016; Gabriel, 2022).

Similarly, Wu et al. (2014) investigated the relationship between early math ability, math anxiety, and internalizing-externalizing behaviors in a group of 366 second and third grade students. The research showed that math achievement is negatively correlated with MA. In regard to the gender differences in math performance, the UN published news in concerning the global fight for gender equality and opportunity, specifically in relation to gender differences in math performance, showing that girls are now performing as well as boys in the classroom when it comes to mathematics - despite the fact they are hampered by numerous hurdles (United Nations, 2022).

METHOD

Participants

The number of primary school students participating in the research was N=173. Four out of seven elementary public schools responded positively and finally participated in the research, after getting the necessary ethical approvals. Schools were selected randomly. Also, all students were attending sixth grade at public schools in Attica, Greece; in the research sample, 69 were male students and 104 were female students.

Procedure

The research was empirical and used the quantitative approach using as a tool a questionnaire consisting of 15 statements/items regarding MA and a test in mathematics containing exercises on fractions. In the MA questionnaire, a five-point Likert scale indicated whether the students "strongly agree" (weighted 5 points), "agree" (weighted 4 points), "maybe" (weighted 3 points), "disagree" (weighted 2 points) or "strongly disagree" (weighted 1 point). Then, the following formula was used to find the mean value of each statement for each student and for their gender add all the weights, then divide by 8, number of positive feelings statements, or by 7, number of negative feeling statements. In order to calculate the mean value of all negative feeling or positive feeling statements for the two genders, the mean values of all boys or girls were summed up and divided by 69 (number of boys in the sample) or by 104 (number of girls in the sample). At the end, the total scores for each feeling question were converted into a percentage, and rounded off to the nearest integer. In addition, the mean value of positive feelings and negative feelings was calculated for each gender.

Next the mean value of the 15 statements/items of MA questionnaire as well as the mean value of mathematics test for each student was calculated. For the interpretation of MA questionnaire's mean value, a higher mean value indicates higher math anxiety. In addition, the math test was formulated based on the teacher's textbook using similar items.

Instruments

The data was collected via a structured questionnaire related to the student experience of MA, and was administered in schools. The questionnaire consisted of two parts. Part A requested information**,** about gender and age, while the fifteen questions in Part B collected information about the MA level of the students; 7 questions on negative feelings and 8 questions on positive feelings. The questionnaire consisted of the following statements (1, 4, 5, 6, 8, 11, 13, 15 on positive feelings about mathematics and 2, 3, 7, 9, 10, 12, and 14 on negative feelings about math):

1. I have usually been at ease in math classes.
2. I see math as a subject I will rarely use.
3. I'm not good at math.
4. Generally, I have felt secure about doing math.
5. I'll need mathematics for my future work.
6. I usually get good grades in mathematics.
7. I don't think that I could do advanced math.
8. It wouldn't bother me at all to take more math classes.
9. Even though I study, math seems unusually hard for me.
10. I am unable to think clearly when working in mathematics.
11. Knowing mathematics will help earn a living.
12. Math has been my worst subject.
13. I think I could handle more difficult mathematics.
14. I'm not the type to do well in mathematics.
15. Math doesn't scare me at all.

The questionnaire was designed to measure student math anxiety and to examine math anxiety gender differences. Response options followed a 5-point Likert scale; Not at all – 1, 2, 3, 4, 5-Very much.

The next measurement scales were used as references: The Mathematics Anxiety Rating Scale (MARS), the Mathematics Anxiety Scale (MAS), and the Abbreviated Math Anxiety Scale (AMAS). For example number 6 "I usually get good grades in mathematics" derive from the statement "Waiting to get a mathematics test returned in which you expected to do well" of MARS survey. MARS and MAS are the most widely cited measurements used to explore math anxiety (Luttenberger et al., 2018) and the AMAS is acknowledged as suitable for testing math anxiety for students between 11 and 16 years old (Devine et al., 2012), while it can also work competently in contexts with cultural and linguistic diversity (Cipora et al., 2015).

In addition, the math test examined students' both mathematical knowledge of fractions and how well they can use that knowledge to solve problems. The problem given to the students was "*five friends ordered two same size pizzas*" as seen in the Figure 2.

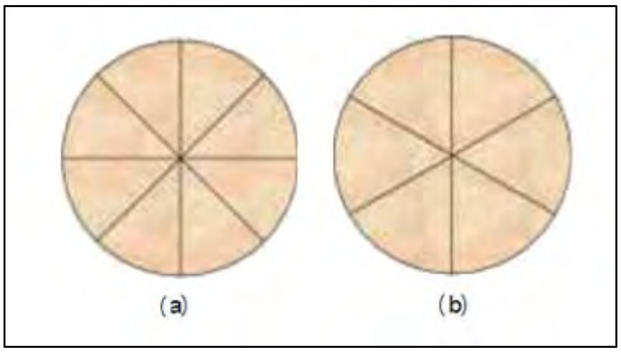

Figure 2: The shape of the two pizzas

A. *Vasilis ate 5 pieces of pizza (a), Georgios ate 3 pieces of pizza (b), and Margarita ate one piece of pizza (a).*

1. Write the fraction of the pizza they ate separately.

   Vassilis ate…….of pizza (a), Georgios ate…….. of pizza (b), and Margarita ate …… of pizza (a).

2. Write each fraction of the pizza they ate in ascending order using the less-than sign.

   Answer: ……………………………………………………………………

B. *Georgios ate* $\frac{3}{8}$ *of pizza (a) and Marcos ate* $\frac{3}{6}$ *pizza (b). Who ate more pizza?*

Check the correct answer: I) Georgios   II) Marcos

C. *Georgios ate* $\frac{3}{6}$ *of pizza (a) and Maria ate* $\frac{4}{8}$ *of pizza (b). Use number lines to compare the fractions.*

Check the correct answer: i. Georgios ate more

ii. They ate the same amount of pizza

iii. Maria ate more

D. *Vasilis ate* $\frac{2}{8}$ *of pizza (a) and* $\frac{3}{6}$ *of the same pizza.*

i. Total part of pizza eaten by Vasilis:

Check the correct answer: A. $\frac{5}{14}$ B. $\frac{3}{4}$ C. $\frac{6}{48}$

ii. Maria said "Only a slice of pizza (a) is left".

I. Agree II. Disagree

Data analysis

Statistical tests were conducted, one non-parametric test and two parametric tests. The non-parametric Kruskal-Wallis test was applied to assess significant differences in the dependent variable "math test score" by the independent variable "math anxiety". Two independent t-tests were conducted for the dependent variables "Mean scores of Negative feeling" and "Mean scores of Positive feeling" across the independent variable "Students' Gender".

The SPSS 21 statistical software was the major statistical tool processing the data while the Excel application was used for the other calculations; the percentages and the mean values.

Reliability and Validity

It was determined to establish the validity and reliability of the research instrument because it had been altered to fit the research. The criteria set for the evaluation survey questionnaire put out by Good and Scates (1954) followed in determining the validity of the research instrument. Good and Scates instrument had eight criteria (this research used an instrument of ten criteria, see Appendix 3) for validation of research instruments by experts: 1) Is the question on the subject? 2) Is the question perfectly clear and unambiguous? 3) Does the question get at something stable? Something relatively deep-seated, well-considered, non-superficial, and not ephemeral, but something which is typical of the individual or the situation? 4) Does the question pull? 5) Do the responses show a reasonable range of variation? 6) Is the information obtained consistent? 7) Is the item sufficiently inclusive? 8) Is there a possibility of using an external criterion to evaluate the questionnaire?

The validity of the research tool was evaluated by three experts, yielding a validity rating of 4.55; mean value of the eleven number-responses. This validity index shows that the redesigned research instrument had excellent levels of validity. According to Tavakol and Dennick (2011), the alpha range should be between 0.7 and 0.9. Cronbach alpha computed and determined reliability alpha overall coefficient to be 0.87. Cronbach alpha for negative feelings was 0.88 and for positive feelings Cronbach alpha was 0.86. These reliability coefficients demonstrated a high level of instrument reliability.

RESULTS

Results for MA

Primarily, the questionnaire was designed to provide information about the MA at the primary educational level. Secondarily, but not of lesser importance, the questionnaire was used to gather data regarding the gender differences with regard to MA. The following Figure 3 demonstrates that girls have lower confidence than boys concerning their math skills.

The results concerning positive feelings about mathematics statements 1, 4, 5, 6, 8, 11, 13, 15), show that girls have a lower score than boys. However, in statement 4, "Generally I have felt secure about trying math", as well as in statement 6, "I usually get good grades in mathematics" the girls' percentage is quite high, demonstrating that girls are competitive. On the other hand, it is worth noting that girls scored very low compared to boys in all positive-feeling statements, hence, reporting greater emotional stress towards mathematics.

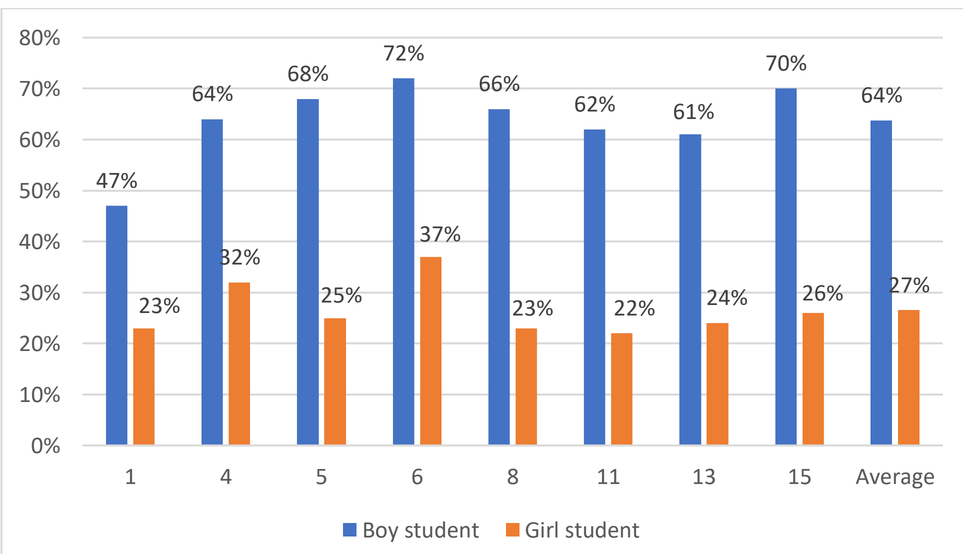

Figure 3: Gender percentages for the positive-feeling statements

In coherence with the previous results, the bar graph in Fig. 4 revealed a high percentage of negative feelings for the girls suggesting a 'handicap' in relation to math skills. It can be seen from the results of the negative-feeling scores about math statements 2, 3, 7, 9, 10, 12, 14) in Fig. 4. Girls have a much higher score than boys. Therefore, the results depicted in Figure 4 support Figure 3 findings associated with the undoubtedly negative influence math anxiety has on girl students. Furthermore, this suggests a strong negative emotional reaction towards math on behalf of girls. It can be seen that the percentages of statement 10, "I am unable to think clearly when working in mathematics" are of great interest; the corresponding percentage of girls was 65% and that of boys was 32%. It may well be argued that these high percentages revealed that both genders had experienced difficulties when they were dealt with math assignments.

Moreover, the girls' high-percentage score (74%) in statement 9, "Even though I study, math seems unusually hard for me", highlights issues relevant to the instruction of mathematics in sixth grade. Therefore, issues related to instructional problems are a challenge for teachers to consider and deal with. Although the results showed a higher rate of mathematical anxiety for girls than boys, even boys were exposed to a moderate level of math anxiety.

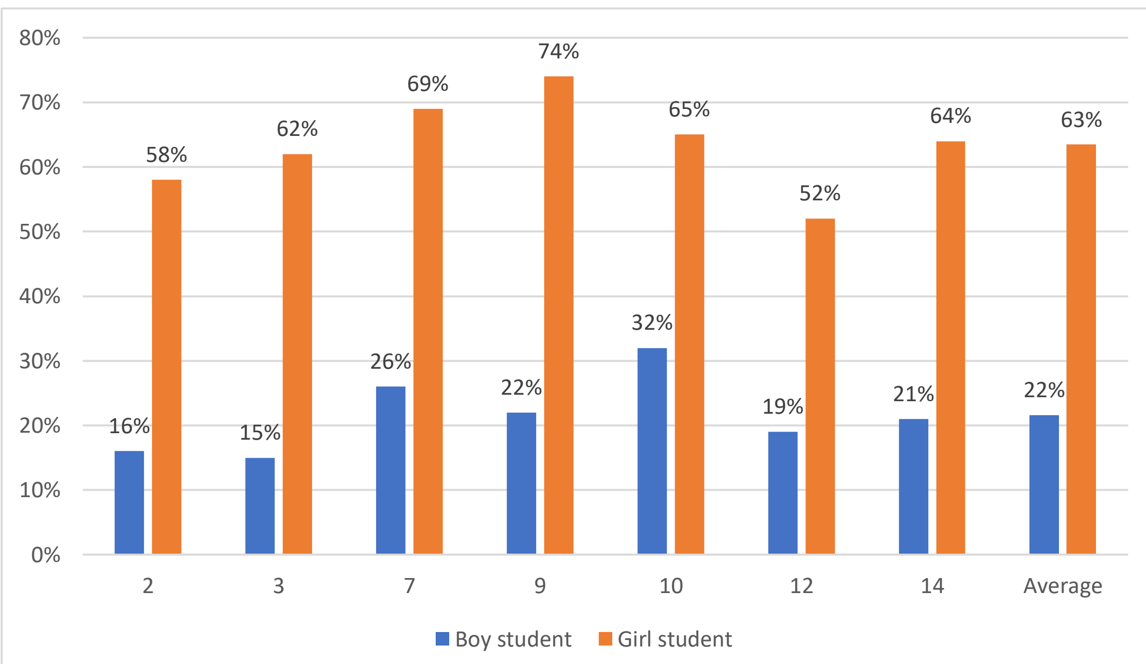

Figure 4: Gender percentages for the negative-feeling statements

Next, Table 1 summarizes the results of all the previous data from Figure 3 and Figure 4 concerning the percentages for each statement of positive and negative feelings about mathematics for both genders.

Statement	Emotion	Boy	Girl
1. I have usually been at ease in math classes.	positive	47%	23%
2. I see math as a subject I will rarely use.	negative	16%	58%
3. I'm not good at math.	negative	15%	62%
4. Generally, I have felt secure about doing math.	positive	64%	32%
5. I'll need mathematics for my future work.	positive	68%	25%
6. I usually get good grades in mathematics.	positive	72%	37%
7. I don't think that I could do advanced math.	negative	26%	69%
8. It wouldn't bother me at all to take more math classes.	positive	66%	23%
9. Even though I study, math seems unusually hard for me.	negative	22%	74%
10. I am unable to think clearly when working in mathematics.	negative	32%	65%
11. Knowing mathematics will help earn a living.	positive	22%	62%
12. Math has been my worst subject.	negative	19%	52%
13. I think I could handle more difficult mathematics.	positive	61%	24%
14. I'm not the type to do well in mathematics.	negative	21%	64%
15. Math doesn't scare me at all.	positive	70%	26%

Table 1: Display (%) of gender emotions about Mathematics

Results of Gender math anxiety test

For a better understanding of the results, the percentages of the mean value of positive and negative responses were calculated for each gender. By looking at Figure 5, it is obvious that math anxiety exists among sixth grade students. Meanwhile, as it appears in Figure 5, positive feelings about math were a lot higher for boys (55% boys - 27% girls) in contrast to negative feelings (63% girl students - 22% boy students). These results determined that there is a positive relationship between math anxiety and gender, female students exhibiting higher negative feelings than their male student counterparts.

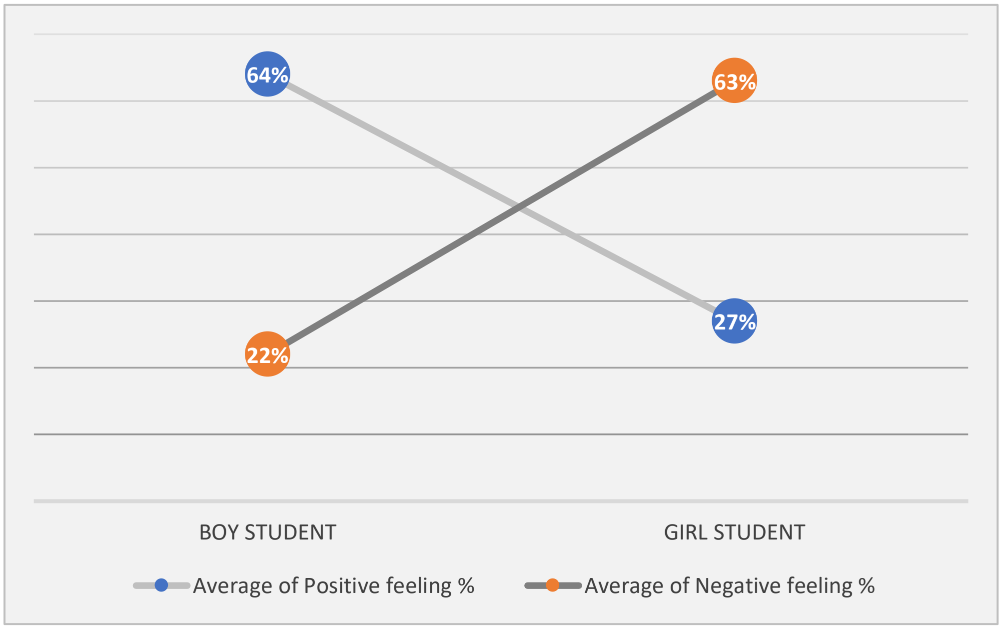

Figure 5: Gender positive and negative feeling average (%) values

For a statistical assessment of the differences between the two genders, two independent t-tests were conducted, as the data followed the normal distribution (Table 2). To check the normality for the dependent variables "Mean Score of Negative feeling" and "Mean Score of Positive feeling" across the two levels of the independent variable "Students' Gender", boy students and girl students, the Shapiro-Wilk test was applied to the sample.

	Students' Gender	Shapiro-Wilk
Mean Score of Positive feeling	Girl Students	0.087
	Boy Students	0.095
Mean Score of Negative feeling	Girl Students	0.075
	Boy Students	0.064

Table 2: Normality tests for both Negative and Positive feelings

Moreover, there were no outliers (Figure 6).

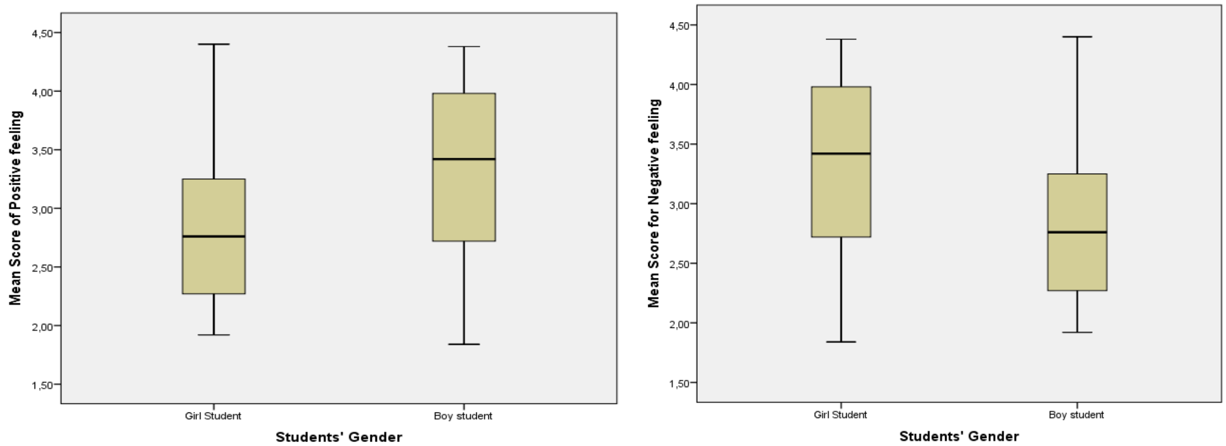

Figure 6: Boxplots for both "Mean Score" variables

Levene's test assumption for equality of variances was found to be violated for the present analysis; for the variable "Mean scores of Negative feeling" the significance of Levene's test was 0.012< 0.05 and for the variable "Mean scores of Positive feeling", 0.014< 0.05. Due to this violation, independent t-tests not assuming homogeneity of variance were computed.

The results of the independent t-test samples showed there was a significant difference in the Mean scores of Negative feeling for Girl Students (M=3.32, SD=0.77) and Boy students (M=2.91, SD=0.67). This test was statistically significant, $t\,(171) = 3.84$, $p < .05$; d=0.56. The effect size for this analysis (d = 0.56) was found to be Cohen's (1988) convention for a medium effect (d=.05). These results indicate that boy students experienced less negative feeling than did girls did.

Next, the t-test results of the independent samples showed there was a significant difference in the Mean scores of Positive feeling for Girl Students (M=2.89, SD=0.65) and Boy students (M=3.38, SD=0.75). This test was statistically significant, $t(171) = -4.6$, p < .05; d=0.71. The effect size for this analysis (d = 0.71) was found to be Cohen's (1988) convention for a large effect (d=.08). These results indicate that girl students experienced less positive feeling than boys did.

Also, because the 95% CI (Confidence Interval) of the difference does not include zero; lower limit at 0.207 and upper limit at 0.648- in the "Mean scores of Negative feeling", it can be derived as a conclusion that the difference in the negative feeling between the two genders does exist in the population. Moreover, the test for the variable "Mean scores of Positive feeling" returned the same result, as the lower limit of CI was at -0.710 and the upper limit was at -0.284.

The following Table 3 describes the results of the two independent t-tests of the variables "Mean scores of Negative feeling" and "Mean scores of Positive feeling" across the variable "Students' Gender".

	Students'bGender	*M*	*SD*	*p*	*Cohen's d*
Mean Score of Negative feeling	Girl Students	3.32	0.77	0.00	0.56
	Boy Students	2,91	0.67		
Mean Score of Positive feeling	Girl Students	2.89	0.65	0.00	0.71
	Boy Students	3.38	0.75		

Table 3: The results of the two independent t-tests

Results of Math test score and MA score

The reliability of all 15 statements was good giving a Cronbach alpha of 0.865.

The Shapiro-Wilk normality test determined for both continuous variables Math test score and MA score, that the p-values were more than 0.05 (Table 4). Thus, the distributions of math test scores for these five "New Negative Feeling" groups are not normally distributed. For that reason, a non-parametric statistical test was suitable to analyze the data.

Variable	*p*
MA score	.088
Math test score	.344

Table 4: The Shapiro-Wilk normality test

Additionally, the scatterplot suggested that there was a linear relationship between the continuous variables, Math test score and MA score, and that the assumption of homoscedasticity was not violated. A Pearson's correlation analysis indicated that there was a very strong, negative, and significant correlation between Math test score and MA score, r (171) = - 0.956, $p < 0.01$ (Table 5).

Variable	M	SD	1	2
1. MA score	2.89	0.89	--	
2. Math test score	7.29	1.30	-0.956	--

Table 5: Pearson's correlation analysis

Next an ANCOVA test was conducted giving a significant difference in mean Math test score, with F (1,170) = 4.608, p=0.006, between the two genders, whilst adjusting for MA score. The partial Eta Squared value was 0.81 indicating a large effect size that is gender explains approximately 81% of the variance in the dependent variable Math test score.

On the whole, these findings imply that gender has a significant effect on the dependent variable Math test score when considering the effects of MA score. This underscores the significant impact of gender on the variable Math test score when accounting for the influence of the variable MA score.

DISCUSSION

Mathematics is a discipline studied almost all over the world. However, research shows that some students don't like to study the subject because they believe it is difficult. The research complements pieces of the puzzle called MA, looking at this phenomenon from the Primary Education's point of view, where there is a gap in literature during the COVID-19 pandemic.

According to the study, the results strongly indicated that MA is an existing phenomenon in children who attend Primary School (Beilock et al., 2010; Vukovic et al., 2013; Wu et al., 2014; Hill et al., 2016), specifically eleven to twelve-year-old children. This emotional state appeared when students crossed the line of the Growth Zone and entered the Anxiety Zone in the *Growth Zone Model* (Cipora et al., 2015). Thus, the importance of teaching Mathematics in a more organized manner is highlighted.

In addition, the research findings are in agreement with the results of various studies which determined significant differences in the levels of MA according to gender, with the girl students being more vulnerable to the effects of MA (e.g. Griggs, et al., 2013; Bieg et al., 2015; Ferguson et al., 2015; OECD, 2015; Foley, et al. 2017; Van Mier et al., 2019). This result is in line with the conclusions of Coronado-Hijón (2017), Ayuso et al. (2020) and Arnal-Palacián et al. (2022), MA being a significant factor**,** negatively affecting overall girl students' feelings. However, the research findings contradict the findings of Puteh and Khalin (2016), who found no significant differences between the genders.

Furthermore, this study revealed unfavorable effects of math anxiety in math performance, which are consistent with the findings of Yuan et al. (2023) regarding mathematics performance and MA. According to numerous studies (e.g. Nunez-Pena et al., 2013; Foley et al., 2017; Gunderson et al., 2018; Zhang et al., 2019; Siaw et al., 2021; Yuan et al., 2023), MA is a major cause of issues relevant to learning mathematical concepts. This is because it inhibits students' performance. Moreover, according to the study, boy students performed higher than girl students in the math test, which is contrary to assertions made by the United Nations (United Nations, 2022). From the previous discussion the research question was effectively addressed by the study, as it investigated the impact of MA on the academic performance of sixth-grade students in primary education during the COVID-19 pandemic.

Summarizing the results, the study confirmed the presence of MA among eleven to twelve-year-old children, highlighting the emotional distress experienced when students transitioned from the Growth Zone to the Anxiety Zone in the Growth Zone Model. Furthermore, it was found that there were considerable differences in math anxiety between genders; with girls being more susceptible to it. The study also showed that there is a negative relationship between MA and math performance, which means that any presence of math anxiety has an inhibitory effect on learning mathematics. These results demonstrate the significance of structured and supportive mathematics teaching in elementary schools and the importance of specific approaches for helping children overcome math anxiety.

The research made significant progress towards addressing the research question by providing empirical evidence of the impact of math anxiety on academic performance in sixth-grade students. In addition, it expands upon the existing body of literature by validating the presence of MA among sixth graders and its negative impact on math performance, notably among female students. Additionally, the study illuminated the interplay between gender, math anxiety, and academic performance, underscoring the significance of targeted interventions in order to mitigate MA's negative effects.

A limitation to the study was certain school Principals' denial to participate in the research, the reason for the denial of access to these schools being, as suspected, the concern about a health threat to the school population. In addition, the study examined one of the three sub-categories (Luttenberger et al., 2018) of MA that nearly all researchers agree upon. So, future studies could focus on all three MA sub-categories or on each one separately.

Due to the fact that MA negatively impacts math learning, even in online environments, the education systems must develop effective strategies to strengthen the self-esteem of students. In addition, since it seems that female students have higher MA than male students, appropriate approaches should be deployed focusing on the characteristics of the students and their learning needs. Moreover, studies should be focused on interventions to minimize MA. Finally, additional research should be undertaken on the nature of MA in order to find out the origins of and its effects on other aspects.

CONCLUSION

The research results show that MA can significantly affect math performance of sixth graders; specifically among girls. It is important to put in place teaching methods that take care of different learning styles and solve specific problems for students affected by MA; however, by understanding MA' s nature and consequences educators can include interventions fostering primary school learning milieu for success in mathematics.

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No potential conflict of interest was reported by the author.

Data availability statement (DAS)

Upon request, the corresponding author will supply the data supporting the study's conclusions upon reasonable inquiry

References

[1] Abbasi, M., Samadzadeh, M., & Shahbazzadegan, B. (2013). Study of Mathematics Anxiety in High School Students and it's Relationship with Self-esteem and Teachers' Personality Characteristics. *Procedia - Social and Behavioral Sciences*, *83*, 672-677, https://doi.org/10.1016/j.sbspro.2013.06.127

[2] Aguillon, S., Siegmund, G-F., Petipas, R., Drake, A., Cotner, S., & Ballen, C. (2020). Gender Differences in Student Participation in an Active-Learning Classroom. *CBE—Life Sciences Education*, *19*, Article 2. https://doi.org/10.1187/cbe.19-03-0048

[3] Arnal-Palacián, M., Arnal, A., & Blanco, C. (2022). Math Anxiety in Primary Education during Covid-19 Confinement: Influence on Age and Gender. *Acta Scientiae*, *24*(1), 145-170. https://doi.org/10.17648/acta.scientiae.6745

[4] Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology: General, 130,* 224–237. https://doi.org/10.1037/0096-3445.130.2.224

[5] Ayuso, N., Fillola, E., Masiá, B., Murillo, A. C., Trillo-Lado, R., Baldassarri, S., Cerezo, E., Ruberte, L., Mariscal, D.M., & Villarroya-Gaudó, M. (2020). Gender Gap in STEM: A Cross-Sectional Study of Primary School Students' Self-Perception and Test Anxiety in Mathematics. *IEEE Transactions on Education*, *64*(1), 40-49. https://doi.org/10.1109/TE.2020.3004075

[6] Bao, W. (2020). COVID-19 and Online Teaching in Higher Education: A Case Study of Peking University Human. *Behavior and Emerging Technologies*, *2*, 113–115. https://doi.org/10.1002/hbe2.191

[7] Beilock, S.L., Gunderson, E.A., Ramirez, G., & Levine, S.C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences of the United States of America*, *107* (5), 1860-1863. https://doi.org/10.1073/pnas.0910967107

[8] Bertoletti, A., Biagi, F., Di Pietro, G., & Karpiński, Z. (2023).The effect of the COVID-19 disruption on the gender gap in students' performance: a cross-country analysis. *Large-scale Assessments in Education*, *11*, Article 6. https://doi.org/10.1186/s40536-023-00154-y

[9] Bieg, M., Goetz, T., Wolter, I., & Hall, N. (2015). Gender stereotype endorsement differentially predicts girls' and boys' trait-state discrepancy in math anxiety. *Frontiers in Psychology*, *6*, Article 1404. https://doi.org/10.3389/fpsyg.2015.01404

[10] Bozkurt, A., Koseoglu, S., & Singh, L. (2019). An analysis of peer reviewed publications on openness in education in half a century: Trends and patterns in the open hemisphere. *Australasian Journal of Educational Technology*, *35*(4), 68-97. https://doi.org/10.14742/ajet.4252

[11] Bozkurt, A., & Sharma, RC. (2020). Education in normal, new normal, and next normal: Observations from the past, insights from the present and projections for the future. *Asian Journal of Distance Education*, *15*(2), 1–5. https://doi.org/10.5281/zenodo.4362664

[12] Caviola, S., Primi, C., Chiesi, F., & Mammarella, I. C. (2017). Psychometric properties of the Abbreviated Math Anxiety Scale (AMAS) in Italian primary school children. Learning and Individual Differences, 55, 174– 182. doi: https://doi.org/10.1016/j.lindif.2017.03.006

[13] Cemen, P. B. (1987). *The nature of mathematics anxiety*. Oklahoma State University. https://eric.ed.gov/?id=ED287729

[14] Cipora, K., Szczygiel, M., Willmes, K., & Nuerk, H.C. (2015). Math anxiety assessment with the abbreviated math anxiety scale: Applicability and usefulness: Insights from the Polish adaptation. *Frontiers in Psychology*, *6*, Article 1833. https://doi.org/10.3389/fpsyg.2015.01833

[15] Cohen, J. (1988). *Statistical power and analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

[16] Coronado-Hijón, A. (2017). The Mathematics Anxiety: a transcultural perspective. *Procedia - Social and Behavioral Sciences*, 237, 1061-1065. https://doi.org/10.1016/j.sbspro.2017.02.155

[17] Crompton, H., Burke, D., Jordan, K., & Wilson, S. W. G. (2021). Learning with technology during emergencies: A systematic review of K-12 education. *British Journal of Educational Technology*, *52*, 1554–1575. https://doi.org/10.1111/bjet.13114

[18] Devine, A., Fawcett, K., Szucs, D., & Dowker, A. (2012). Gender differences in mathematics anxiety and the relation to mathematics performance while controlling for test anxiety. *Behavioral and Brain Functions*, *8*(33), 1–9. https://doi.org/10.1186/1744-9081-8-33

[19] Devine, A., Hill, F., Carey, E., & Szűcs, D. (2018). Cognitive and emotional math problems largely dissociate: Prevalence of developmental dyscalculia and mathematics anxiety. *Journal of Educational Psychology*, *110*(3), 431-444. http://dx.doi.org/10.1037/edu0000222

[20] Di Pietro, G. (2023). The impact of Covid-19 on student achievement: Evidence from a recent meta-analysis. *Educational Research Review*, *39*, Article 100530. https://doi.org/10.1016/j.edurev.2023.100530

[21] Dowker, A., Ashcraft, M., & Krinzinger, H. (Eds.). (2012). The Development of Attitudes and Emotions Related to Mathematics [Special issue]. *Child Development Research,* Article 124939. https://doi.org/10.1155/2012/238435

[22] Dowker, A., Sarkar, A., & Looi, C. Y. (2016). Mathematics Anxiety: What Have We Learned in 60 Years? *Frontiers in Psychology*, *7*, Article 508. https://doi.org/10.3389/fpsyg.2016.00508

[23] Drabowicz, T. (2014). Gender and digital usage inequality among adolescents: A comparative study of 39 countries. *Computers & Education, 74*, 98-111. https://doi.org/10.1016/j.compedu.2014.01.016

[24] Dreger, R. M., & Aiken, L. R., Jr. (1957). The identification of number anxiety in a college population. *Journal of Educational Psychology*, *48*(6), 344–351. https://doi.org/10.1037/h0045894

[25] Ferguson, A.M., Maloney, E.A., Fugelsang, J., & Risko, E.F. (2015). On the relation between math and spatial ability: The case of math anxiety. *Learning and Individual Differences*, *39*, 1–12. https://doi.org/10.1016/j.lindif.2015.02.007

[26] Flores, M. A., & Gago, M. (2020). Teacher Education in Times of COVID-19 Pandemic in Portugal: National, Institutional and Pedagogical Responses. *Journal of Education for Teaching*, *46*(4), 507-516. https://doi.org/10.1080/02607476.2020.1799709

[27] Foley, A., Herts, J., Borgonovi, F., Guerriero, S., Levine, S., & Beilock, S. (2017). The Math Anxiety-Performance Link: A Global Phenomenon. *Current Directions in Psychological Science*, *26* (1), 52–58. https://doi.org/10.1177/09637214166724

[28] Fore, H. H. (2020). A Wake-Up Call: COVID-19 and its Impact on Children's Health and Wellbeing. *Lancet Global Health*, *8*(7), 861 – 862. https://doi.org/10.1016/S2214-109X(20)30238-2

[29] Gabriel, F. (2022). Maths Anxiety – And How to Overcome it. *Significance*, *19*(1), 34–35. https://doi.org/10.1111/1740-9713.01612

[30] Ghosh, R., Dubey, M. J., Chatterjee, S., & Dubey, S. (2020). Impact of COVID-19 on children: special focus on the psychosocial aspect. *Minerva Pediatrica*, *72*(3), 226-235. https://doi.org/10.23736/S0026-4946.20.05887-9

[31] Good, C., & Scates, D. (1954). *Methods of Research: Educational, Psychological and Sociological*. New York: Appleton-Century-Crofts.

[32] Griggs, M.S., Rimm-Kaufman, S.E., Merritt, E.G., & Patton, C.L. (2013). The Responsive Classroom approach and fifth grade students' math and science anxiety and self-efficacy. *School Psychology Quarterly*, *28*(4), 360–373. https://doi.org/10.1037/spq0000026

[33] Gunderson, E. A., Park, D., Maloney, E. A., Beilock, S. L., & Levine, S. C. (2018). Reciprocal relations among motivational frameworks, math anxiety, and math achievement in early elementary school. *Journal of Cognition and Development,* *19*(1), 21–46. https://doi.org/10.1080/15248372.2017.1421538

[34] Haase, V. G., Júlio-Costa, A., Pinheiro-Chagas, P., Oliveira, L. F. S., Micheli, L. R., & Wood, G. (Eds.) (2012). Math self-assessement, but not negative feelings, predicts mathematics performance of elementary school children [Special issue]. *Child Development Research*, *10*(1). https://doi.org/10.1155/2012/982672

[35] Hanushek, E. & Woessmann, L. (2020, September). *The economic impacts of learning losses* (OECD Education Working Papers No. 225). https://doi.org/10.1787/21908d74-en

[36] Harari R. R., Vukovic R. K., Bailey S. P. (2013). Mathematics anxiety in young children: an exploratory study. *The Journal of Experimental Education*, *81*(4), 538-555. https://doi.org/10.1080/00220973.2012.727888

[37] Hembree, R. (1990). The Nature, Effects, and Relief of Mathematics Anxiety. *Journal for Research in Mathematics Education*, *21*(1), 33-46. https://doi.org/10.2307/749455

[38] Hill, F., Mammarella, I. C., Devine, A., Caviola, S., Passolunghi, M. C., & Szûcs D. (2016). Maths anxiety in primary and secondary school students: gender differences, developmental changes and anxiety specificity. *Learning and Individual Differences*, *48*, 45–53. https://doi.org/10.1016/j.lindif.2016.02.006

[39] Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). The Difference between Emergency Remote Teaching and Online Learning. *EDUCAUSE Review*. https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning

[40] Jameson, M. M. (2013). The Development and Validation of the Children's Anxiety in Math Scale. *Journal of Psychoeducational Assessment*, *31*(4), 391–395. https://doi.org/10.1177/0734282912470131

[41] Johnston-Wilder, S., Lee, C., Garton, L., Goodlad, S., & Brindley, J. (2013, November 18-20). *Developing Coaches for Mathematical Resilience*. ICERI 2013: 6th International Conference on Education, Research and Innovation, Seville, Spain. http://oro.open.ac.uk/38989/.

[42] Kargar, M., Tarmizi, R.A., & Bayat, S. (2010). Relationship between Mathematical Thinking, Mathematics Anxiety and Mathematics Attitudes among University Students. Procedia Social and Behavioral Sciences *8*(3), 537-542. https://doi.org/10.1016/j.sbspro.2010.12.074.

[43] Khasawneh, E., Gosling, C., & Williams, B. (2021). What impact does maths anxiety have on university students? *BMC Psychology*, *9*, Article 37. https://doi.org/10.1186/s40359-021-00537-2

[44] Krinzinger, H., Kaufmann, L., & Willmes, K. (2009). Math Anxiety and Math Ability in Early Primary School Years. *Journal of Psychoeducational Assessment*, 27(3), 206–225. https://doi.org/10.1177/0734282908330583

[45] Lee, J. (2020). Mental health effects of school closures during COVID-19. *The Lancet Child and Adolescent Health*, *4*(6). https://doi.org/10.1016/S2352-4642(20)30109-7

[46] Liu, J. J., Bao, Y., Huang, X., Shi, J., & Lu, L. (2020). Mental health considerations for children quarantined because of COVID-19. *The Lancet Child & Adolescent Health*, *4*(5), 347 – 349. https://doi.org/10.1016/S2352-4642(20)30096-1

[47] Luttenberger, S., Wimmer, S., & Paechter, M. (2018). Spotlight on math anxiety. *Psychology research and behavior management*, *11*, 311–322. https://doi.org/10.2147/PRBM.S141421

[48] Mata, L., Monteiro, V., Peixoto, F., Santos, N. N., Sanches C., & Gomes, M. (2022). Emotional profiles regarding maths among primary school children – A two-year longitudinal study. *European Journal of Psychology of Education, 37*(1), 391–415. https://doi.org/10.1007/s10212-020-00527-9

[49] Mitchell, L., & George, L. (2022). Exploring mathematics anxiety among primary school students: Prevalence, mathematics performance and gender. *International Electronic Journal of Mathematics Education*, 17(3), Article em0692. https://doi.org/10.29333/iejme/12073

[50] Moorhouse, B. L. (2020). Adaptations to a face-to-face initial teacher education course 'forced' online due to the COVID-19 pandemic. *Journal of Education for Teaching*, *46*(4), 609–611. https://doi.org/10.1080/02607476.2020.1755205

[51] Núñez-Peña, M.I., Suárez-Pellicioni, M., & Bono, R. (2013). Effects of Math Anxiety on Student Success in Higher Education. *International Journal of Educational Research, 58*, 36-43. https://doi.org/10.1016/j.ijer.2012.12.004

[52] OECD (2001). Learning to change: ICT in schools. Paris: Organisation forEconomic Co-operation and Development. https://www.oecd.org/digital/learningtochangeictinschools.htm

[53] OECD (2013*). PISA 2012 Results: Ready to Learn: Students' Engagement, Drive and Self-Beliefs*, (Volume III). Paris: OECD Publishing. https://doi.org/10.1787/19963777

[54] OECD (2015). *The ABC of Gender Equality in Education: Aptitude, Behaviour, Confidence*. Paris: OECD Publishing.

[55] O'Leary, D., Fitzpatrick, C., & Hallett, D. (2017). Math Anxiety Is Related to Some, but Not All, Experiences with Math. *Frontiers in Psychology*, *8*, Article 2067. https://doi.org/10.3389/fpsyg.2017.02067

[56] Passolunghi, M.C. (2011). Cognitive and Emotional Factors in Children with Mathematical Learning Disabilities. *International Journal of Disability Development and Education 58*(1), 61–73. https://doi.org/10.1080/1034912X.2011.547351

[57] Patrinos, H.A. (2022). Learning loss and learning recovery. *Decision, 49*(2), 183–188. https://doi.org/10.1007/s40622-022-00317-w

[58] Puteh, M., & Khalin, S.Z. (2016). Mathematics Anxiety and Its Relationship with the Achievement of Secondary Students in Malaysia. International Journal of Social Science and Humanity *6* (2), 119-122. https://doi.org/10.7763/IJSSH.2016.V6.630

[59] Phelps, C., & Sperry, L. L. (2020). Children and the COVID-19 pandemic. *Psychological Trauma: Theory, Research, Practice, and Policy*, *12*(S1), 73–75. 5 ISSN: 1942-9681 http://dx.doi.org/10.1037/tra0000861

[60] Ramirez, G. Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2013). Math Anxiety, Working Memory, and Math Achievement in Early Elementary School. *Journal of Cognition and Development*, *14*(2), 187-202. https://doi.org/10.1080/15248372.2012.664593

[61] Rubinsten, O., & Tannock, R. (2010). Mathematics anxiety in children with developmental dyscalculia. *Behavioral and Brain Functions*, *6*(1), 46-58. https://doi.org/10.1186/1744-9081-6-46.

[62] Shapiro, M. O., Gros, D. F., & McCabe, R. E. (2020). Intolerance of Uncertainty andSocial Anxiety while Utilizing a Hybrid Approach to Symptom Assessment. *International Journal of Cognitive Therapy*, *13*(1), 189-202. https://doi.org/10.1007/s41811-020-00068-5

[63] Schleicher, A. (2020). *The Impact of COVID-19 on Education: Insights from "Education at a Glance 2020"*. OECD Publishing. https://eric.ed.gov/?id=ED616315

[64] Siaw, E.S., Shim, G.T.G., Azizan, F.L., & Shaipullah, N.M. (2021). Understanding the relationship between students' mathematics anxiety levels and mathematics performances at the foundation level. *Journal of Education and Learning*, *10*(1), 47–54. https://doi.org/10.5539/jel.v10n1p47

[65] Sorvo, R., Koponen, T., Viholainen, H., Aro, T., Räikkönen, E., Peura, P., Dowker, A., & Aro, M. (2017). Math anxiety and its relationship with basic arithmetic skills among primary

school children. *The British Journal of Educational Psychology*, *87*(3), 309-327. https://doi.org/10.1111/bjep.12151

[66] Spinelli, M., Lionetti, F., Pastore, M., & Fasolo, M. (2020). Parents' stress and children's psychological problems in families facing the COVID-19 outbreak in Italy. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.01713

[67] Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International journal of medical education*, *2*, 53–55. https://doi.org/10.5116/ijme.4dfb.8dfd

[68] Villavicencio, F. T., & Bernardo, A. B. I. (2016). Beyond math anxiety: Positive emotions predict mathematics achievement, self-regulation, and self-efficacy. *Asia Pacific Education Researcher*, *25*(3), 415-422. https://doi.org/10.1007/s40299-015-0251-4

[69] Vukovic, R. K., Kieffer, M. J., Bailey, S. P., & Harari, R. R. (2013). Mathematics anxiety in young children: Concurrent and longitudinal associations with mathematical performance. *Contemporary Educational Psychology*, *38*(1), 1-10. https://doi.org/10.1016/j.cedpsych.2012.09.001

[70]UNESCO (2020). Education: From disruption to recovery. https://en.unesco.org/covid19/educationresponse

[71] United Nations (2022, April 27). *Girls' performance in maths 'starting to add up to boys', says UNESCO*. UN News. https://news.un.org/en/story/2022/04/1117082

[72] Van Mier, H.I., Schleepen, T.M.J., Van den Berg, F.C.G. (2019). Gender Differences Regarding the Impact of Math Anxiety on Arithmetic Performance in Second and Fourth Graders. *Frontiers in Psychology*, *9*, Article 2690. https://doi.org/10.3389/fpsyg.2018.02690

[73] Wang, Z., Lukowski, S. L., Hart, S. A., Lyons, I. M., Thompson, L. A., Kovas, Y., Mazzocco, M. M. M., Plomin, R., & Petrill, S. A. (2015). Is Math Anxiety Always Bad for Math Learning? The Role of Math Motivation. *Psychological Science*, *26*(12), 1863–1876. https://doi.org/10.1177/0956797615602471

[74] Werner, K., & Woessmann, L. (2023). The Legacy of Covid-19 in Education. *Economic Policy*, eiad016. https://doi.org/10.1093/epolic/eiad016

[75] Wongwatkit, C., Panjaburee, P., Srisawasdi, N., & Seprum, P. (2020). Moderating effects of gender differences on the relationships between perceived learning support, intention to use, and learning performance in a personalized e-learning. *Journal of Computers in Education, 7*, 229–255. https://doi.org/10.1007/s40692-020-00154-9

[76] World Economic Forum (2022, November 14). *Here's how COVID-19 affected education- and how we can get children's learning back Broom*, https://www.weforum.org/agenda/2022/11/covid19-education-impact-legacy/

[77] Wu, S. S., Willcutt, E. G., Escovar, E., & Menon, V. (2014). Mathematics achievement and anxiety and their relation to internalizing and externalizing behaviors. *Journal of Learning Disabilities, 47*(6), 503–514. https://doi.org/10.1177/0022219412473154

[78] Yuan, Z., Tan, J., & Ye, R. (2023). A Cross-national Study of Mathematics Anxiety. *The Asia-Pacific Education Researcher*, Article 32, 295–306. https://doi.org/10.1007/s40299-022-00652-7

[79] Zawacki-Richter, O., Conrad, D., Bozkurt, A., Aydin, C. H., Bedenlier, S., Jung, I., Stöter, J., Veletsianos, G., Blaschke, L. M., Bond, M., Broens, A., Bruhn, E., Dolch, C., Kalz, M., Kondakci, Y., Marin, V., Mayrberger, K., Müskens, W., Naidu, S., … Xiao, J. (2020). Elements of Open Education: An Invitation to Future Research. *The International Review of Research in Open and Distributed Learning*, *21*(3), 319-334. https://doi.org/10.19173/irrodl.v21i3.4659

[80] Zhang, J., Zhao, N., & Kong, Q. P. (2019). The Relationship between Math Anxiety and Math Performance: A Meta-Analytic Investigation. *Frontiers in psychology*, *10*, Article 1613. https://doi.org/10.3389/fpsyg.2019.01613

APPENDIX

1. MA Test

Instruction: Check the box below that represents your most appropriate response to each statement -Not at all – 1, 2, 3, 4, 5-Very much-using check mark, an X, to the following statements:

e.g.

Statement	1 Not at all	2	3	4	5 Very much
…………		X			

STATEMENTS

Statement	1	2	3	4	5
1.I have usually been at ease in math classes					
2. I see math as a subject I will rarely use					
3. I'm not good at math					
4. Generally, I have felt secure about doing math					
5. I'll need mathematics for my future work					
6. I usually get good grades in mathematics					
7. I don't think that I could do advanced math					
8. It wouldn't bother me at all to take more math classes					
9. Even though I study, math seems unusually hard for me					
10. I am unable to think clearly when working in mathematics					
11. Knowing mathematics will help earn a living					
12. Math has been my worst subject					
13. I think I could handle more difficult mathematics					
14. I'm not the type to do well in mathematics					
15. Math doesn't scare me at all					

2. Validity: Extended Evaluation survey questionnaire

Survey instrument validation rating scale

Instruction: Please specify your level of agreement or disagreement on the next agree-disagree scale for the therteen statements.

Circle the number that describes how much you agree with each statement

1 - Strongly Disagree 2 - Disagree 3 - Undecided 4 - Agree 5 - Strongly Agree

Criteria	Level of Agreement or Disagreement				
The items in the instrument are relevant to answer the objectives of the study.	1	2	3	4	5
The items in the instrument can obtain depth to constructs being measured.	1	2	3	4	5
The instrument has an appropriate sample of items for the construct being measured.	1	2	3	4	5
The items and their alternatives are neither too narrow nor limited in its content.	1	2	3	4	5
The items in the instrument are stated clearly.	1	2	3	4	5
The items on the instrument can elicit responses which are stable, definite, consistent and not conflicting.	1	2	3	4	5
The layout or format of the instrument is technically sound.	1	2	3	4	5
The responses on the scale show a reasonable range of variation.	1	2	3	4	5
The instrument is not too short or long enough that the participants will be able to answer it within a given time.	1	2	3	4	5
The instrument is interesting such that participants will be induced to respond to it and accomplish it fully.	1	2	3	4	5
The instrument as a whole could answer the basic purpose for which it is designed.	1	2	3	4	5

Comments and Suggestions:

. . . .
. . . .
. . . .
. . . .

Signature over Printed Name

3. **Correlations**

		MA mean score	Math test mean score
MA mean score	Pearson Correlation	1	-,956**
	Sig. (2-tailed)		,000
	N	173	173
Math test mean score	Pearson Correlation	-,956**	1
	Sig. (2-tailed)	,000	
	N	173	173

**. Correlation is significant at the 0.01 level (2-tailed).

4. ANCOVA TEST

Tests of Between-Subjects Effects

Dependent Variable: Math test mean score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	267,390[a]	2	133,695	924,612	,000	,916
Intercept	1910,889	1	1910,889	13215,362	,000	,987
MA_score	265,881	1	265,881	1838,785	,000	,915
Gender	,666	1	,666	4,608	,006	,806
Error	24,581	170	,145			
Total	9493,630	173				
Corrected Total	291,972	172				

a. R Squared = ,916 (Adjusted R Squared = ,915)

5. **Descriptive Statistics**

	N	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
MA mean score	173	2,8904	,88839	,164	,185	,347	,367
Math test mean score	173	7,293	1,3029	,079	,185	-,531	,367
Valid N (listwise)	173						