

# Math Anxiety and its Relation to the Success of Mathematical Problems

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**Abstract** – Math anxiety is widespread problem described as worry and tension while doing mathematics. The aim of research is to determine whether there is a correlation between math anxiety and the performance of elementary school students in solving mathematical problems at the second level. . The theoretical part of the thesis contains information and empirical findings about math anxiety and solving mathematical problems. The research sample was comprised of 138 (46,38 % girls and 53,62 % boys) 9th grade elementary learners from Slovak republic. The data were collected by the questionnaire of our own design comprising : the modified abbreviated math anxiety scale, the state-trait anxiety inventory, and the math test. Quantitative data analysis methods included descriptive statistics and Spearman coefficient as a measurement of correlation between variables. The results have revealed that mathematics anxiety has significant correlation ( $R = - 0.401$ ;  $p = 1,09216.10^{-6}$ ,  $p < 0.01$ ) with the success of mathematical problems and significant correlation ( $R = 0.608$ ;  $p = 2,44249.10^{-15}$ ,  $p < 0.01$ ) with the mathematics achievement. 36,23 % of the participants reported high math anxiety, and a further 18% were at least somewhat affected by it. The results confirm that the mAMAS questionnaire is an appropriate tool for determining the level of mathematical anxiety among pupils in Slovakia.

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**Keywords** – Math anxiety, elementary school, student performance, mathematical problems.

## 1. Introduction

Math anxiety can be described as strong negative emotions toward math, and is defined as a feeling of tension, apprehension, or fear that interferes with math performance [1]. Math anxiety is a long-standing problem in education. Attention from both educators and researchers is needed to help students reach their full academic potential [2].

Children as young as six feel fear, rage, and despair because of “mathematics anxiety”, a condition which can cause physical symptoms and behavior problems in class, according to a study.

Learners in both primary and secondary school can find themselves locked in a cycle of despair, suffering from anxiety which harms their math performances, which in turn leads to increased anxiety.

The models of study [3] suggest that math anxiety can affect math performance in three ways (indirectly and directly):

1. indirectly through the ability of working memory - this is a so-called "affective decline" in mathematical performance,
2. indirectly through the processing of symbolic numbers,
3. direct influence of Math anxiety on performance in mathematics.

## 2. Material and Method

Based on the research findings of [4], [5], [6], [7] in the field of mathematical anxiety as a problem of didactics of mathematics and psychology, the following goals were chosen:

- Identify and evaluate the possible relationship between mathematical anxiety and the success of solving mathematical problems.
- Find out in which mathematical area students subjectively felt the greatest insecurity, fear.
- Evaluate the possible relationship between mathematical anxiety and mathematical success.

- Analyze the possible relationship between mathematical anxiety and state anxiety, trait anxiety of pupils.

- Examine pupils' reporting of mathematical anxiety in the actual learning of mathematics and in the situation related to pupil assessment.

- To find out which thematic units of mathematics cause fear, anxiety in students and subsequently compare the obtained data from the point of view of the gender of students.

The research sample consisted of 138 participants, pupils of 9th grade of elementary school. Age of the participants was 14-15 years. The 9th grade is the last year of elementary school in Slovakia. That was the reason for our choice. They are 46% of girls and 54% of boys in the research sample.

We established the following hypotheses:

H1: There is a relationship between math anxiety and success in solving math problems assignments by pupils.

H2: There is a relationship between math anxiety and math achievement.

H3: There is a relationship between math anxiety and state in pupils from the research sample.

H4: There is a relationship between math anxiety and trait anxiety among pupils.

Currently, no validated instrument for measuring math anxiety is used in Slovakia. Therefore, we decided to verify the AMAS questionnaire in Slovak conditions.

The Abbreviated Math Anxiety Scale - AMAS questionnaire [8] is a suitable 9-item questionnaire for quickly measuring math anxiety in pupils aged 14 and over. The internal consistency of the AMAS questionnaire [8] is satisfactory ( $\alpha = .90$ ), as well as for the subscales used to measure learning math anxiety (Learning Math Anxiety - LMA,  $\alpha = .85$ ) and math evaluation anxiety (MEA,  $\alpha = .88$ ).

The State-Trait Anxiety Inventory (STAI) is a commonly used measure of trait and state anxiety [9]. It can be used in clinical settings to diagnose anxiety and to distinguish it from depressive syndromes. It is also often used in research as an indicator of caregiver distress [10], [11].

The self-constructed questionnaire was utilized to obtain data on the specific areas within mathematics that induce the most significant fear and anxiety among the students. The test of mathematics to determine mathematical knowledge. It consisted of 4 problems from the fields of geometry, operations with numbers, combinatorics and probability, relations, and tables. We used problems from the national testing for 9th graders.

Descriptive statistics (percentage expressions, frequencies, graphs, minimum values, maximum values, averages, standard deviations), verification of research hypotheses through Spearman's rank correlation coefficient were used as methods of statistical processing.

### 3. Results

One of the challenges faced by the participants was the task of selecting three thematic units, out of all the available options, in which they personally experience the highest levels of fear and anxiety. We used thematic units from the updated curriculum. The obtained data as a scale was evaluated using the calculation of average values according to paper [12]. Pupils chose from 26 thematic units. Surface and volume of solids (pyramidal, cone, prism, sphere), equations and inequalities, word problems and fractions were marked as the most difficult units. Pupils were the least afraid of the thematic units Pythagorean theorem, numerical operations with natural numbers, and numerical operations with whole numbers.

Table 1. Fear of the math problem and average success

	Fear of the given math problem		Average success
	n	%	%
Problem 1 (Geometry and measurement)	33	23.91	63,53
Problem 2 (Numbers, variable, numerical operations with numbers)	25	18.12	53,38
Problem 3 (Combinatorics, probability, statistics)	25	18.12	58,70
Problem 4 (Relations, functions, tables, and diagrams)	12	6.69	51,45
Unmarked problem	43	31,16	
Total	138	100.00	

Legend: n = number of participants; % = percentage representation of participants

To assess the first working hypothesis H1, the following null hypothesis  $H_0$  was established: The statistical characteristics of mathematical anxiety and success in solving mathematical problems are independent. In contrast to the tested null hypothesis, the alternative hypothesis  $H_1$  was put forward: The statistical characteristics of mathematical anxiety and the success of solving mathematical problems are dependent.

Due to the non-fulfilment of the normal distribution condition of the student's success in written work, Spearman's rank correlation coefficient R was used for data analysis. At the significance level of 0.01, a moderately strong indirect dependence was demonstrated ( $R = -0.401$ ;  $p = 1.09216.10^{-6}$ ,  $p < 0.01$ ). There is a moderate degree of relationship between the statistical features of math anxiety and success in solving math problems. (Table 2).

Table 2. Level of math anxiety (MA) in mAMAS and success in solving math problems

Marks in mathematics	1	2	3	4	5
Success	1 – 0,9	0,89-0,75	0,74-0,5	0,49– 0,3	0,29-0,0
	%	%	%	%	%
Low level of MA	53.3	60	31.6	16.7	27.3
Moderate level of MA	36.7	12	34.2	8.3	18.2
High level of MA	10	18	34.2	75	54.5

The investigation of the hypothesis H2 was based on the statistical analysis of the null hypothesis  $H_0$ : The statistical properties of math anxiety and the average grades in mathematics from the past three years are believed to be unrelated based on the null hypothesis ( $H_0$ ). However, the alternative hypothesis ( $H_1$ ) posits that there is dependence between the statistical characteristics of math anxiety and the grade point average on the last three report cards. Table 3 presents the findings regarding the relationship between math anxiety and the overall success of students in mathematics, measured by the average grades in the mathematics subject on the last three classifications. Since the grade point average data did not meet the condition of normal distribution, we used Spearman's rank correlation coefficient R to analyse them. A strong direct relationship was demonstrated at the 0.01 significance level ( $R = 0.608$ ;  $p = 2.44249.10^{-15}$ ,  $p < 0.01$ ) between math anxiety and mathematical success. Among the statistical features of math anxiety and success in math, there is a significant one degree of binding.

Table 3. Math anxiety score in mAMAS [13] and overall math achievement

Success	1 –	2-	3-	4–	R	p
	1.99	2.99	3.99	4–		
	%	%	%	%		
Low level of MA	60.0	40.0	27.2	0.0		
Moderate level of MA	32.5	30.0	20.5	0.0		
High level of MA	2.5	30.0	52.3	100.0		
Total	100	100	100	100	0.608	2.44.10 <sup>-15</sup>

Figure 1 shows a tendency in which the number of participants with a minimal degree of math anxiety decreases with the deterioration of students' success in mathematics, and on the contrary, more students with a worse grade average than 3 showed a high degree of math anxiety than students with a better grade average.

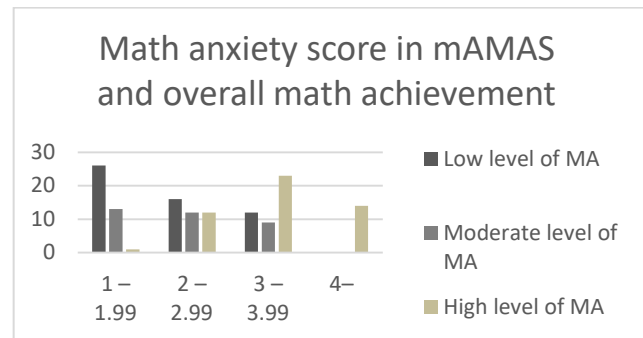


Figure 1. Math anxiety score in mAMAS and overall math achievement

The stated results correspond to the findings of research [14], in which students who were not successful in mathematics showed a higher degree of math anxiety and at the same time less motivation and self-confidence in mathematics than successful students. The results showed a significant statistical dependence between the mathematical success presented by the student's final assessment and the degree of mathematical anxiety ( $F(2,180) = 5.03$ ,  $p = 0.007$ ,  $\eta^2 = 0.053$ ).

Furthermore, the relationship between mathematical success measured by the mAMAS scale [13] and the level of current anxiety measured by the questionnaire for measuring trait and state anxiety [15] in pupils was investigated (Table 4). Obtained results showed that out of 93 participants who did not show current anxiety at the given moment, 48 pupils did not even show an increased degree of math anxiety, 20 pupils were measured with a moderate degree of math anxiety and 25 pupils with a high degree of math anxiety. Math anxiety was not measured in 6 students, mild math anxiety was measured in 14 pupils, and 25 pupils showed a high degree of math anxiety.

Table 4. The level of math anxiety and the level of state anxiety

	The level of state anxiety in normal (1-6 stens) %	Increased state anxiety level (7-10 stens) %	R	P
Low level of MA	51.61	13.33		
Moderate level of MA	21.51	31.11		
High level of MA	26.88	55.56		8.09.
Total	100	100	0.466	$10^{-9}$

The verification of the working hypothesis H3 took place through the null hypothesis H<sub>0</sub>: Statistical characteristics of mathematical anxiety and the level of anxiety of pupils are independent and of the alternative hypothesis H<sub>1</sub>: Statistical characteristics of mathematical anxiety and the degree of anxiety of pupils they are dependent. At a significance level of 0.01, a moderately strong direct relationship was measured between math anxiety measured by the mAMAS scale [13], and the level of current anxiety measured by the questionnaire for measuring trait and state anxiety [15] in the STAI - X1 section dependence (R = 0.466; p = 8.09.10-9, p < 0.01). Between math anxiety and the degree of current anxiety, a moderate degree of connection was measured at the significance level of 0.01. The researches [8], [9] measured a correlation of .26 between their AMAS questionnaire and the STAI X.

Our research also focused on assessing the relationship between math anxiety measured by the mAMAS questionnaire [13] and pupils' anxiety (Table 5) measured by the State- trait anxiety questionnaire [15]. Out of 90 pupils with unproven anxiety as a personality trait, 45 pupils did not have math anxiety; a moderate level of math anxiety was measured in 22 students and a high degree of math anxiety in 23 participants. Of the 48 participants with an increased level of anxiety, pupils did not show math anxiety, 12 students had a moderate level of math anxiety, and 27 pupils had a high degree math anxiety.

Table .5 Level of math anxiety and the level of trait anxiety

	The level of trait anxiety in normal (1-6 stens) %	Increased trait anxiety level (7-10 stens) %	R	p
Low level of MA	50.00	18.75		
Moderate level of MA	24.44	25.00		
High level of MA	25.56	56.25		4.92
Total	100	100	0.444	$.10^{-8}$

Examining the relationship between math anxiety and anxiety as an individual trait established within the framework of hypothesis H4 using the null hypothesis H<sub>0</sub>: Statistical features math anxiety and the degree of students' current anxiety are independent, and the alternative hypothesis H<sub>1</sub>: Statistical features of math anxiety and the degree of students' current anxiety are dependent.

With 99% confidence, the alternative hypothesis was accepted that there is a statistically significant relationship between math anxiety mAMAS [13] and the level of anxiety measured by the questionnaire for measuring state anxiety and trait anxiety [15] in the STAI - X2 segment dependence (R = 0.444; p = 4.92.10-8, p < 0.01). There is a moderately strong direct relationship between students' mathematical anxiety and anxiety. The resulting correlation coefficient was within the range of measured correlations of studies [16], [17], [8] respectively 0.35, 0.566, 0.28. So we can confirm that math anxiety is closely related to trait anxiety. This is an important finding for us, as we can claim that the mAMAS questionnaire is a suitable tool for measuring math anxiety even for pupils in Slovakia.

It is important for us to include the results (Table 6) that relate to the specific aspects or partial forms of mathematical anxiety. A participant exhibiting elevated mathematical learning anxiety (LMA) was defined as a student whose total score on items 1, 3, 6, 7, and 9 of the mAMAS scale [13] reached 15 points or more. Increased math anxiety in the student's evaluation situation, test anxiety (MEA), was indicated by the student scoring 12 or more points on items 2, 4, 5, and 8 of the mAMAS scale [13].

Table 6. Mathematics learning anxiety (LMA) and in an assessment situation (MEA) as measured by the mAMAS questionnaire

	n	%
Increased LMA	5	3.62
Increased MEA	69	50.00

Legend: n = number of participants; % = percentage representation of participants

Based on the obtained data, increased mathematical anxiety during learning mathematics was measured in 5 students (3.62%). In total, increased math anxiety related to the situation associated with assessment and testing was demonstrated in 69 students (50%). We can consider this as a direct effect of math anxiety on performance in mathematics, as we stated in the introduction [3].

According to [18] at least a third of pupils, in our case half of the participants, experienced anxiety in a test situation, and less than 4% of pupils show anxiety in situations of learning mathematics.

In the researches [1], [8], [19] a significant correlations between math anxiety and test anxiety were found.

#### 4. Discussion

Consistent with the studies [5], [6], [20], [21], [23] the following findings were presented in the article to fulfill the stated research objectives. 60.87% of the participants showed a moderate or high degree of math anxiety, and a moderately strong indirect relationship ( $R = -0.401$ ;  $p = 1.09216 \cdot 10^{-6}$ ,  $p < 0.01$ ) was found between math anxiety and the success of solving math problems in written work. A significant degree of connection, a moderately strong direct dependence ( $R = 0.608$ ;  $p = 2.44249 \cdot 10^{-15}$ ,  $p < 0.01$ ) was demonstrated between math anxiety and the average grade of students on the last three classifications. The number of participants with a minimal degree of math anxiety decreased with worsening success rate of students in mathematics, and the number of students with a high degree of math anxiety increased with the deterioration of the students' grade point average. The results showed a moderately strong direct relationship between math anxiety and state anxiety ( $R = 0.466$ ;  $p = 8.09 \cdot 10^{-9}$ ,  $p < 0.01$ ) and anxiety ( $R = 0.444$ ;  $p = 4.92 \cdot 10^{-8}$ ,  $p < 0.01$ ) measured by the State-trait anxiety questionnaire [15]. An important result was also the finding that the most feared thematic units of the teaching subject mathematics are the units Ilan, cylinder, cone, sphere, their volume, and surface, solving linear equations and inequalities and word problems, based on which we recommend that teachers be cautious when teaching the mentioned subjects. Our previous studies have shown that math anxiety interferes with cognitive processing. With math anxiety, there is a decrease in working memory capacity, which is also related to students' results in mathematics [24], [25].

#### 5. Conclusion

Regarding the obtained results, we would like to put forth recommendations for future research on the topic of math anxiety, as well as acknowledge the limitations of our own study. We consider it important to standardize a suitable research tool for measuring math anxiety aimed at elementary school students at the national level.

We believe that the mAMAS used in this manner could be one of the research tools under consideration. Subsequently, it would be possible to find out in the framework of longitudinal research at what age math anxiety affects students, or whether it increases or culminates with increasing age.

We consider the setting of only one problem presenting one of the four thematic areas to be one of the limits of the research due to time constraints. For this reason, the results of the examined item cannot be generalized. Furthermore, we recommend measuring test anxiety at the same time as math anxiety to find out the correlation of the mentioned phenomena, which is also one of the limits of our research. Qualitative research could be carried out with pupils, in which a high degree of math anxiety was measured, which would probably benefit the expansion of new horizons and the theoretical framework of math anxiety. Finally, it would be appropriate after diagnosing math anxiety in pupils to carry out an experiment with the aim of comparing the results of the experimental and control groups in connection with the prevention or elimination of mathematical anxiety.

The presence of the phenomenon of mathematical anxiety in the educational process is evident. Due to the visible technicalization of society, it would be desirable to create a space for the diagnosis of mathematical anxiety with the aim of eliminating the pedagogical-psychological problem, the creation of preventive measures and such conditions in teaching that will evoke positive emotions in students. Teachers and parents should pay attention to the reduction of math anxiety and use all possible ways to present mathematics to students in an inspiring and positive light to prevent math avoidance with possible impact on the student's future.

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