International Journal of Engineering and Science Invention (IJESI)
ISSN (Online): 2319-6734, ISSN (Print): 2319-6726
www.ijesi.org ||Volume 14 Issue 5 May 2025 || PP 65-70

Investigating the Impact of Math Anxiety on Academic Performance in Primary School Students: A Review of Competing Theories

Madhusmita Das, Rudra Pratap Jena, Sarthak Kumar Sahoo
Assistant Professor (Mathematics) Department of BSH, Raajdhani Engineering College, Bhubaneswar
Assistant Professor (Mathematics) Department of BSH Nalanda Institute of Technology Bhubaneswar
Lecturer in Mathematics, Chanakya Higher Secondary School, Bhubaneswar

Abstract
For some children, arithmetic can be particularly difficult due to math-related anxiety or stress. This study examined the impact of math anxiety on the performance of 6- to 8-year-olds. Children completed a math anxiety survey, a mental rotation task, and a series of arithmetic problems. Researchers also tracked whether students used simple counting strategies or more advanced methods like decomposition and fact retrieval. The results showed that children with higher anxiety levels made more mistakes and were more likely to use basic strategies. Two major conclusions emerged: math anxiety can negatively affect both working memory and confidence, which are essential for solving math problems effectively. These findings emphasize the importance of addressing emotional influences on learning. Helping children manage their anxiety and boost their self-confidence may encourage the use of more efficient problem-solving techniques and lead to better math performance. This research offers valuable insight into supporting anxious learners in mathematics.

Keywords
Disregard the numbers, Math Proficiency, Awareness of Space, Recognizing Shapes, Reasoning, Thinking Critically, Young
Students, Early Learning, Development of the Mind, Methods of Learning

---

Date of Submission: 15-05-2025 Date of Acceptance: 26-05-2025

I. Introduction

Math anxiety, marked by worry or fear during arithmetic tasks, can appear as early as first grade. It comes in two forms: **state anxiety**, which is brief and task-related, and **trait anxiety**, a long-term tendency to feel anxious about math. Trait anxiety is measured separately from general test anxiety. Research shows girls often report higher math anxiety than boys, possibly due to emotional openness or societal stereotypes. High math anxiety is also linked to poor math performance. This study explored the **disruption** and **lowered competency** accounts in 6- to 8-year-olds, aiming to better understand how anxiety affects early math learning.

The cognitive disruption theory

The disruption account suggests that individuals with high math anxiety focus on fear of failure, which drains working memory—the mental space needed for problem-solving. This split attention hinders performance. Studies show anxiety weakens working memory and learning outcomes. Neuroimaging reveals that less anxious adults solve math more automatically, while anxious ones rely on effortful control to manage worry, reducing efficiency. Behaviourally, anxious children avoid advanced strategies like decomposition or retrieval and instead use simpler counting methods, often on fingers. This reliance on basic techniques limits math success. To improve performance, interventions should target anxiety reduction through therapy, relaxation, or emotional regulation techniques.

The deficit theory (often known as the diminished competency account)

According to the "reduced competency account", math anxiety results from issues with "computation and geometric processing", which cause bad feelings and recurrent failures in the subject. More so then the opposite, there is evidence that early low mathematical achievement predicts later worry. Research also shows that people who experience a lot of arithmetic nervousness tend to have less accurate spatial and numerical abilities. It's possible that "females express higher math anxiety" because to gender variations in "spatial ability", particularly in "mental rotation". According to some research, a fear of working in space may be a contributing factor. Nevertheless, results in early infants are conflicting, and more trustworthy research is required to elucidate these connections.

The present investigation

Using a combined approach with young children, this study investigated two important theories: "the disruption account" and "the lower competency account". The researchers assessed the following: "mental rotation", "fluid and verbal reasoning", "arithmetic performance", "strategy use" (counting vs. higher-level), and "trait math anxiety". They hypothesized that using higher-level methods will mitigate the unfavorable relationship between math anxiety and performance (H1). Research on children reveals conflicting results, however studies on adults indicate a connection between math anxiety and spatial abilities. As a result, this study also investigated the connection between early learners' "math anxiety" and "spatial skills".

Method

The study involved 163 middle school pupils from Austria and the Netherlands. Because of their poor performance or incomplete data, sixteen students were eliminated. The majority of participants were either Dutch (24.5%) or Austrian (57.1%), with others representing a variety of countries. Students with weak Dutch proficiency or developmental difficulties were not allowed to participate. Parents used an online survey to report diagnoses. Informed consent was acquired, and the University of Vienna provided ethical approval. Families who participated were given gift cards.

Empty Cell	M (SD)/n (%)	Min	Max
Mean age (years)	7.68 (0.62)	6.44	8.99
Gender (number of boys)	94 (57.7%)		
WISC-V vocabulary (raw)	25.48 (5.52)	7	35
WISC-V vocabulary (standardized)	12.20 (2.93)	1	19
WISC-V matrix reasoning (raw)	15.79 (3.67)	5	26
WISC-V matrix reasoning (standardized)	11.04 (2.46)	3	18
Math anxiety			
Score	21.98 (11.53)	0	53
Mental rotation			
Number correct	50.99 (6.71)	28	56
Arithmetic performance			
Number correct	14.91 (4.60)	1	20
Arithmetic strategies			
Number of counting strategies	3.87 (5.12)	0	19
Number of higher-level mental strategies	12.60 (7.10)	0	20
Number of guesses	0.39 (1.00)	0	6
Using concrete material or fingers in arithmetic task			
Number of concrete material (pearls)	0.36 (1.69)	0	17
Number of fingers	2.72 (4.67)	0	19

Power analysis

To ascertain the necessary sample size for verifying the study's hypotheses, an a priori power analysis was performed using G*Power 3.1. A sample of 159 students was needed, assuming a low to moderate effect size for the indirect effect of higher-level mental strategies, with a significance level of $p < .05$, power of.80, and seven predictors (such as counting methods, math anxiety, and control factors). Similarly, the required sample size for the reduced competency account was 159, based on prior research that used six variables and reported minor to moderate effects (e.g., $r = .22$ to $-.38$). The study had the power to adequately test the disruption and lowered competency accounts, with 163 youngsters in the final sample.

Anxiety in mathematics

To assess children's trait-level math anxiety, a German version of a widely used English questionnaire was employed. It measured four areas: fear of poor performance, attitude toward math, emotional reactions (like sadness), and self-assessed ability. Each was evaluated using seven everyday math scenarios (e.g., homework), with children responding on a 5-point visual scale featuring expressive faces. Two non-math examples ensured comprehension. Scores per dimension ranged from 0 to 28. We combined "unhappiness" and "worry" scores for an overall anxiety score (0–56), with higher scores indicating greater anxiety. The tool showed strong reliability and a significant negative link to math performance.

Arithmetic performance

Children completed 20 addition and subtraction problems involving single- and double-digit numbers, with about half requiring borrowing or regrouping. Problems increased in difficulty and included tasks like basic subtraction (e.g., $8 - 3$), mixed-digit operations (e.g., $17 - 9$), multi-step calculations (e.g., $6 - 2 + 4$), and missing-element problems (e.g., $12 - \_ = 5 + 1$).

Before the main task, kids practiced four simpler examples and were allowed to use any method, including wooden counting sticks. Researchers recorded problem-solving strategies based on children's verbal explanations and actions, classifying them as counting, decomposition, or fact retrieval. Only accurate answers were analyzed statistically.

Statistical analyses

The statistical package IBM SPSS 27 was used for the analyses, and all variables (except from gender) were z-standardized to guarantee comparability. Using bootstrapping with 5000 samples and 95% confidence intervals, mediation analyses were performed using the PROCESS plug-in (Version 4.1) to investigate the disruption hypothesis. Arithmetic performance was the result, and math anxiety, as judged by the "unhappiness" and "worry" aspects, was the predictor. Higher-level techniques and counting were assessed concurrently, with arithmetic strategies serving as the mediators. Age, gender, and verbal and fluid reasoning were all regulated. A hierarchical regression analysis was employed to investigate the reduced competency hypothesis. In the first step, control variables were included, and in the second step, arithmetic performance and mental rotation were entered as predictors. Anxiety related to math was the dependent variable.

II. Results

Descriptive statistics

Empty Cell	M (SD)/n (%)	Min	Max
Mean age (years)	7.68 (0.62)	6.44	8.99
Gender (number of boys)	94 (57.7%)		
WISC-V vocabulary (raw)	25.48 (5.52)	7	35
WISC-V vocabulary (standardized)	12.20 (2.93)	1	19
WISC-V matrix reasoning (raw)	15.79 (3.67)	5	26
WISC-V matrix reasoning (standardized)	11.04 (2.46)	3	18
Math anxiety			
Score	21.98 (11.53)	0	53
Mental rotation			
Number correct	50.99 (6.71)	28	56
Arithmetic performance			
Number correct	14.91 (4.60)	1	20
Arithmetic strategies			
Number of counting strategies	3.87 (5.12)	0	19
Number of higher-level mental strategies	12.60 (7.10)	0	20
Number of guesses	0.39 (1.00)	0	6
Using concrete material or fingers in arithmetic task			
Number of concrete material (pearls)	0.36 (1.69)	0	17
Number of fingers	2.72 (4.67)	0	19

The table above contains descriptive statistics. There was significant variation in math anxiety scores, which ranged from 0 to 53 out of 56. In both the mental rotation and arithmetic tasks, children often provided accurate answers to a good percentage of items, despite notable individual performance variation. Furthermore, the majority of youngsters relied on more sophisticated mental techniques, while fewer employed counting strategies. Rarely were concrete things like wooden beads utilized, and some kids occasionally used finger counting to help with their math. These results demonstrate the variety of tactics used as well as the variations in the children's task performance and math anxiety.Even after adjusting for age, gender, and cognitive ability, the bivariate correlations, which are displayed in the table below, indicated a slight inverse relationship between math anxiety and arithmetic performance. In arithmetic, fewer right answers were associated with more math anxiety. Additionally, math anxiety was negatively correlated with higher-level mental strategies and positively correlated with counting techniques, suggesting that worried kids avoided advanced strategies and preferred counting. Furthermore, there was a favorable correlation between improved arithmetic performance and higher-level techniques. Key characteristics showed a moderate relationship with verbal and fluid reasoning, but performance and strategy utilization were substantially correlated with age. Gender differences showed that females relied more on counting strategies, performed poorer, and experienced higher levels of math anxiety.

Empty Cell	1	2	3	4	5	6	7	8	9
1. Math anxiety		−.173”	.178”	−.198”	−.062	−.007	−.124	.024	.224”
2. Arithmetic performance	−.165”		−.179”	.661”	.297”	.163”	.442”	.567”	−.181”
3. Counting strategies	.098	.042		−.668”	−.120	−.001	−.291”	−.224”	.322”
4. Higher-level mental strategies	−.157”	.467”	−.614”		.237”	.178”	.403”	.513”	−.302”
5. Mental rotation	−.034	.255”	−.061	.170”		.088	.141	.121	−.085
6. Verbal reasoning (WISC-V, raw)							.205”	.245”	.034
7. Fluid reasoning (WISC-V, raw)								.397”	−.012
8. Age									−.122
9. Gender									

Examining the disruption account: An arithmetic-based mediation model

Model	Estimate	SE/SE^t	p	R^2	95% CI
Model without mediators				**.409**	
Intercept	−.014	.062	.819		[−.137, .108]
Math anxiety → Arithmetic performance (c)	**−.134**	**.064**	**.038**		**[−.260, −.007]**
Model with mediators				**.636**	
Intercept	−.007	.049	.879		[−.104, .089]
Math anxiety → Arithmetic performance (c′)	−.076	.051	.136		[−.177, .024]
Model with counting strategies as mediator					
Intercept	.044	.073	.549		[−.100, .187]
Math anxiety → Counting (a)	.093	.075	.217	**.190**”	[−.055, .240]
Counting → Arithmetic performance (b)	**.454**”	**.068**	**<.001**		**[.320, .588]**
Indirect effect (a*b)	.042	.042^t			[−.031, .136]
Model with higher-level mental strategies as mediator					
Intercept	−.035	.063	.582		[−.159, .090]
Math anxiety → Mental strategies (a)	**−.130**”	**.065**	**.047**	**.390*****	**[−.258, −.001]**
Mental strategies → Arithmetic performance (b)	**.765**”	**.078**	**<.001**		**[.610, .919]**
Indirect effect (a*b)	**−.099**”	**.056**^{t}			**[−.224, −.004]**

Math anxiety and control variables explained 40.9% of the variance in children's arithmetic performance, rising to 63.6% when strategy use was included. Anxiety was linked to fewer correct answers and reduced use of advanced strategies, though not basic counting. Once strategies were accounted for, anxiety no longer directly impacted performance, suggesting it affects outcomes mainly by limiting higher-level strategy use.

Analyzing the Hypothesis of Reduced Competency:

Even after controlling for age, gender, and verbal and fluid reasoning, the regression analysis revealed a substantial correlation between math anxiety and poorer arithmetic ability. Math anxiety levels were generally greater among kids who did poorly on math exercises. However, there was no correlation between mental rotation skill and math anxiety. The addition of arithmetic and rotation scores increased the amount of anxiety

variance explained by the control variables from 7.7% to 10.2%, although this increase was not statistically significant (p =.117).

The dependent variable in a hierarchical regression analysis is math anxiety (N = 163)

Empty Cell	Variables	β	T	t Significance	R^2	F (df1, df2)	F Significance
Step 1					**.077**”	**3.289 (4, 158)**	**.013**
Empty Cell	Age	.122	1.430	.155			
Empty Cell	Gender	**.237** “	**3.072**	**.003**			
Empty Cell	Fluid reasoning	**−.167**”	**−1.993**	**.048**			
Empty Cell	Verbal reasoning	−.011	−0.136	.892			
Step 2					.102	2.178 (2, 156)	.117
Empty Cell	Arithmetic performance	**−.206**”	**−2.041**	**.043**			
Empty Cell	Mental rotation	.008	0.100	.921			

Math anxiety was only predicted by performance on difficult arithmetic problems with carryover operations in a different model; performance on easier problems without carryover did not significantly correlate with math anxiety. Researchers looked at whether mental rotation affected math anxiety indirectly by affecting arithmetic ability in a final exploratory analysis. Math anxiety was the result, arithmetic performance was the mediator, and mental rotation was the predictor in a mediation model test. The results indicated a large indirect effect, even though no direct correlation between mental rotation and math fear was anticipated. Math anxiety was adversely correlated with arithmetic performance, which was positively predicted by mental rotation. This implies that anxiety and spatial skills are indirectly related through mathematical aptitude. When arithmetic tasks were divided into different problem types (with or without carryover), this indirect impact vanished.

Talk about

This study explored how math anxiety relates to young children's performance by comparing the disruption and lowered competency accounts. Results showed a small but significant negative link between anxiety and arithmetic accuracy, supporting both theories. Mediation analysis revealed anxious children used fewer advanced strategies, especially on complex tasks, and lower arithmetic skills were tied to spatial ability. Although gender did not affect these relationships, girls reported higher anxiety, relied more on basic strategies, and performed worse—highlighting early gender differences that warrant further investigation.

Advantages and disadvantages

In order to investigate two theoretical stances on arithmetic anxiety, this study looked at important characteristics in a large sample of elementary school students. Notably, there was no correlation between mental rotation and arithmetic anxiety, which is consistent with research aimed at children but not with studies conducted on adults, indicating that this relationship might evolve over time. Our math anxiety measure included both emotional and cognitive components, and the challenges were age-appropriate, eliminating floor or ceiling effects. There are a few restrictions, though. Conclusions on causality are limited by the cross-sectional methodology, and results require experimental and longitudinal research to be validated.

Generalizability is limited by the age range (Grades 1–3), particularly in light of developmental shifts in math-spatial linkages. Potential contributing factors were overlooked by not assessing working memory and spatial anxiety. The fact that math anxiety was assessed following the arithmetic problem may have affected answers depending on how difficult or well the activity was evaluated. To improve measuring techniques, future studies should examine order effects, particularly differentiating between state and trait math anxiety.

Remarks

The disruption and decreased competency explanations were investigated in this study, and both were found to be supported. Children who were worried about math employed fewer cognitively taxing techniques, which is consistent with the disruption theory. The decreased competency explanation was further supported by the fact that math anxiety was associated with arithmetic performance but not with mental rotation, which was indirectly associated with anxiety. Overall, the findings point to a reciprocal link, suggesting that the most successful therapies for lowering math anxiety in elementary school students may combine emotion management with gains in arithmetic and spatial abilities.

Recognitions

This research was supported by the National Science Center in Poland and the Swiss National Science Foundation. Christian Wollmann, Sara Hotz, Jasmin Iller, Hanna Stöckli, and the participating schools and families are all acknowledged. Initial findings were presented at the PAEPS and EARLI conferences.

References

[1]. Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. Current Directions in Psychological Science, **11**, 181–185. doi:10.1111/1467-8721.00196

[2]. Ashcraft, M. H., & Faust, M. W. (1994). Mathematics anxiety and mental arithmetic performance: An exploratory investigation. Cognition & Emotion, **8**, 97–125. doi:10.1080/02699939408408931

[3]. Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. Journal of Experimental Psychology: General, **130**(2), 224. doi:10.1037/0096-3445.130.2.224

[4]. Möhring, W., Moll, L. and Szubielska, M., 2024. Mathematics anxiety and math achievement in primary school children: Testing different theoretical accounts. Journal of Experimental Child Psychology, 247, p.106038.

[5]. Möhring, Wenke, Léonie Moll, and Magdalena Szubielska. "Mathematics anxiety and math achievement in primary school children: Testing different theoretical accounts." Journal of Experimental Child Psychology 247 (2024): 106038..