Redefining Mathematical Jitters: Pioneering A Scale For Children's Anxiety In Numerical Contexts

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Abstract-
Mathematical Anxiety is commonly defined as feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in academic situations and even in daily life**.** It negatively impacts the academic achievements of children. In this study, a Mathematical Anxiety Scale was developed to evaluate mathematical anxiety among primary school students aged between 8 to 10 years. The scale contains twenty-four items that measure mathematical anxiety in six domains: anxiety in doing mathematical calculations, performing mathematical activities, mathematical thinking, mathematical evaluation and doing everyday mathematical tasks. The validation of the scale was done using the data of 250 girls and 237 boys participants. The frequency analysis using SPSS shows the Mean=41.37, Standard Deviation ( ) =7.01, and Median=40.00 as obtained. The criteria of scores developed are: A score above 54 shows extremely high math anxiety, ascore between 46–54 shows high math anxiety while scores 37–45, 29–36, and less than 29 shows moderate math anxiety, low math anxiety, and extremely low math anxiety respectively. The Cronbach Alpha coefficient calculated for the evaluation of the internal consistency was determined as 0.728 and this value shows that the scale had good reliability. With the results of this study, the scale's content validity was evaluated and it was shown to have acceptable valid features in all.

Keywords: Mathematical anxiety, primary school, mathematical thinking, evaluation.

Introduction-
Mathematical anxiety (MA) is commonly defined as **"**feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations**"** (Richardson & Suinn, 1972). In school children, it refers to the feeling of fear, tension, or nervousness experienced by some studentswhen confronted with mathematics-related tasks or situations. It can manifest as a strong negative emotional response towards maths, leading to avoidance of math-related activities, decreased self-confidence, and poorer performance in math-related assessments. Severalfactors can contribute to the development of mathematical anxiety in school children such as negative school experiences (Trujillo & Hadfield, 1999) with mathematics (struggling with concepts, receiving poor grades (Szczygieł & Pieronkiewicz, 2022), or experiencing harsh criticism from teachers or peers (Olson & Stoehr, 2019), pressure to perform high in mathematics, perceiving maths as a difficult subject, social comparison on mathematical achievements (Aldrup, Klusmann & Lüdtke, 2020) , lacking confidence in mathematical skills, fear of making mistakes (AlKandari, 2020) or failing in math-related tasks and ineffective or overly strict instructional practices (Mazana, Suero & Olifage, 2019).
Mathematics performance and mathematics anxiety are negatively correlated. Lower performance on school tests is associated with higher levels of mathematics anxiety (Hembree, 1990; Ma & Kishore, 1997). Mathematical anxiety has a negative impact on mathematics performance; however, poor performance in mathematics is also likely to increase anxiety.

The Structure of Mathematical Anxiety:
Mathematical anxiety can be categorized under different dimensions such as:

1. Anxiety in Processing Calculations-
Anxiety in processing calculations is described as a person's state of worryand nervousness in dealing with calculations

and numeracy (Skagerlund et. al. 2019). He may feel panic at the thought of working with numbers.

2. Anxiety in Doing Mathematical Activities-
Anxiety in doing mathematical activities is meant by the feeling of apprehension or nervousness that a person may experience when engaging in mathematical tasks or activities (Choe et. al. 2019), such as solving problems, completing assignments, or participating in class discussions.

3. Anxiety in Mathematical Thinking-
Anxiety in mathematical thinking is the psychological state of the individual having feelings of apprehension, nervousness, or worry when engaging in the thoughtprocesses required for mathematical problem-solving, reasoning, or analysis (Scheibe et. al. 2023).

4. Anxiety in Mathematical Evaluation-
Anxiety in mathematical evaluation refers to the feelings of worry or tension that a student may experience when taking a test or being evaluated in a math class (Finlayson, 2014). It can stem from a variety of factors such as the pressure to perform well, a fear of failure, or a lack of confidence in math skills.

5. Anxiety in Doing Everyday Mathematical Tasks-
Anxiety in doing everyday mathematical tasks refers to the state of stress sensations that impede the handling of mathematical tasks in a range of everyday situations (Seng, 2015) such as affecting activities like budgeting, cooking, measuring, and time management.

Review of the Literature-
This comprehensive literature review delves into a series of studies that have rigorously investigated the measurement and validation of instruments designed to assess mathematical anxiety within various educational stages and age brackets. The study by Sarvo et al. (2017) meticulously employed a combination of assessment tasks and targeted questions to scrutinize fundamental arithmetic competencies and mathematical anxiety within the Finnish educational landscape. Baloglu & Kocak (2006), on the other hand, carefully constructed a nuanced Likert-type scale to gauge maths anxiety specifically among college-level students, with a focus on three distinct subcategories:
mathematics test anxiety, numerical task anxiety, and mathematics course anxiety. Ng (2012) adopted a multifaceted approach, employing both open-ended responses and a four-point Likert scale to examine mathematical anxiety within secondary school students in Singapore. Meanwhile, Mutlu (2019) presented a unique survey questionnaire underpinned by a three-point Likert scale, capturing diverse facets of math anxietyamong participants in an academic milieu.
The work of Ganley & McGraw (2016) takes a developmental perspective, introducing the MASYC-R, a revised scale tailor-made for young children, underpinned by both original and novel items. Notably, the scale displays a significant level of reliability and validity, thereby enhancing our understanding of mathematical anxiety in early childhood. Hopko et al.'s (2003) research represents a substantial stride, as it yielded the Abbreviated Math Anxiety Scale (AMAS), a succinct yet robust assessment tool distinguished by a compelling combination of internal consistency, test-retest reliability, and convergent/divergent validity, thereby presenting a parsimonious and efficacious approach to appraising mathematics anxiety. Mahmood & Khatoon (2011) contribute an innovative bi-dimensional math anxiety scale, finely designed to encompass positive and negative aspects of this phenomenon, particularly tailored for secondary school and senior secondary school students. In a similar vein, Ko & Yi (2011) engage with the intricate facets of mathematics anxiety through the development and validation of the Mathematics Anxiety Scale for Students (MASS). This meticulously crafted tool, founded upon a comprehensive array of domains, offers a robust avenue for assessing and potentially mitigating math anxiety among Korean middle and high school students.
Hunt et al. (2011) pivot to the British academic context, introduced the Mathematics Anxiety Scale—UK (MAS-UK), an exhaustive 23-item measure that deftly captures the multidimensional nature of mathematical anxiety. The study attained credibility through its extensive utilization of factor analyses and normative data, making it a useful tool to measure math anxiety among British and other European university students. Petronzi et al. (2019) conducted pioneering research by scrutinizing maths anxiety among children aged 4–7 years through the Children's Mathematics Anxiety Scale UK (CMAS-UK).
This tool, developed by analyzing data in different ways, proves to be reliable formeasuring math anxiety. It helps us understand where math anxiety comes from and howit affects children from a young age.
Collectively, these studies contribute to give deep insights into the multifaceted realm of mathematics anxiety assessment. By embracing diverse populations, age cohorts, and educational landscapes, these tools collectively provide a nuanced and sophisticated toolkit that aids researchers and educators in apprehending and effectively addressing this pervasive psychological phenomenon.

Development of Mathematical Anxiety Scale for Children (MASC):
Although there has been a significant amount of study on the mathematical anxiety assessments in adolescents and adults, little work has been done on this relationship in children aged 8 to 12 years. More emphasis has recently been laid to the early development of mathematical anxiety, and new assessments need to be developed for use with this age range. The researcher reported on the creation and validation of the Mathematical Anxiety Scale for Children (MASC)

in the current study.

Research Design-
Certain aspects, such as selection of appropriate research design in relation to the type of study, variables under consideration, the number of respondents, and phenomena to be examined, were carefully reviewed. Then, a one-shot survey design was chosen as a suitable research design for this study. In contrast to the conventional scenario of a statistical survey, a one-shot survey contains only one empirical cycle (research question—data collection—analysis—report), according to Jansen (2010). The variable (mathematical anxiety in children) was examined in its natural state, with no factors manipulated by the researcher. The researcher simply collected datausing the MASC and analysed it on SPSS to produce an objective explanation of the phenomena.

Procedure:
The process of the development of the mathematical anxiety scale involved the following steps.

1. **Review of the existing scales for measuring mathematical anxiety** - In this step, the existing scales for measuring mathematical anxiety among students at various educational levels were reviewed to get an in-depth understanding of the different dimensions of the constructs measured and also about the scale development process and also these existing reviews can be used as references to create this new scale.

2. **Selecting the domains to measure Mathematical Anxiety-** In this phase the domains tomeasure the mathematical anxiety were identified. There were five domains selected thatrelates to mathematical anxiety and constitutes in the development of MASC which are as follows-

a) **Anxiety in Doing Mathematical Calculations-** Anxiety in doing mathematical calculations is described as a person's state of worry and nervousness in dealing with calculations and numeracy. He may feel panic at the thought of working with numbers.
b) **Anxiety in Doing Mathematical Activities-** Anxiety in doing mathematical activities is meant by the feelings of apprehension or nervousness that a person may experience when engaging in mathematical tasks or activities, such as solving problems, completing assignments, or participating in class discussions.
c) **Anxiety in Mathematical Thinking-** Anxiety in mathematical thinking is the psychological state of the individual having feelings of apprehension, nervousness, or worry when engaging in the thought processes required for mathematical problem-solving, reasoning, or analysis.
d) **Anxiety in Mathematical Evaluation-** Anxiety in mathematical evaluation refers to the feelings of worry or tension that a student may experience when taking a test or being evaluated in a math class. It can stem from a variety of factors such as the pressure to perform well, a fear of failure, or a lack ofconfidence in math skills.
e) **Anxiety in Doing Everyday Mathematical Tasks-** Anxiety in doing everyday mathematical tasks refers to the state of stress sensations that impede the handlingof mathematical tasks in a range of everyday situations.

3. **Preliminary Draft of Scale**: At this stage towards the development of the MathematicalAnxiety scale, 35 items of anxiety towards math were written after a careful study and review of related existing literature and discussion with several experienced teachers related to math, education, and psychology. The MA scale included the statements with three-dimensional effects such as Positive (e.g. liking, excitement, pleasant, easiness,) Negative (e.g. fear, dread, nervousness, worry, difficulty), and Neutral (e.g. state of beinginactive, uninvolved,) towards math.

4. **Expert's Opinion-** As soon as the scale's first draft was finished, it was sent for experts' suggestions. In this study, the opinion of six experts, consisting of educationalists, psychologists, and mathematics specialists was taken. Experts were requested to judge the worth of each statement in the developed scale against the following criteria:

- The statement should be in simple and understandable language.
- The statement should be clear and precise so that it is interpreted uniformly by allthe respondents.
- The statement should be relevant i.e. there should be congruence between the statement and the definition of the concept of Mathematical Anxiety as mentioned in this study.

As a result after considering the experts' suggestions some of the statements weremodified and some were omitted. The revised version of the initial mathematical anxiety scale contained 28 items with the instructions required to respond to each item on a threeoptions scale.

Content Validity- During the development of the scale, at the first stage, 35 items were created by scanning the literature and previous mathematical anxiety- related scales. Then opinions were received on the scale-content from some experts including mathematicians and educators and school teachers. However, some of the scale-items were found inappropriate and suggestions were received to reconstruct them in line. Finally, a 28-item Anxiety Scale was created after incorporating the suggestions.

With the reconstructed scale, it was piloted with a group of 100 students from the government primary school. In the

survey, it was concluded that some statements were difficult to understand by the students. As a result, the research team corrected the errors in the scale and recorded the responses of the students. As a result of the opinions obtained, the number of items was determined as 28. The stage, which was structured with expert opinion and pilot implementation, was considered as content validity for the 28 items obtained.

5. **Pilot Study-** In the first step of the pilot study, the mathematical anxiety scale consisting of 28 items was administered to 100 students of primary schools randomly selected from the district Bareilly (UP). The students were from class-3 to 5, with age groups ranging from 8 to 12 years. This study was carried out to determine whether the students had any issues or challenges when responding to the items on the developed scale. After this tryout session, the investigators identified the ambiguities and difficult questions as the students were unable to understand the statements while responding to the items on the scale. After receiving the above feedback, the research team corrected grammatical errors and ambiguities found in the items given in the scale, and record the answers of the student.

In the second stage of the pilot study, the research team went to Government schools of Basic Education of Bareilly district of Uttar Pradesh, India to administer the developed Anxiety Scale on students. This session of data collection for over 500 students took approx one month. While collecting data from the students, the scale included emoticons (as shown in the table below) to remind the students about the statements reflecting the positive, negative, and neutral emotions so that their interest remains while answering the statements. Content in the developed scale after the pilot study has been ensured to be presented in an age-appropriate manner. For the students, any difficult words such as *("ज्यामितीय आकार")* were defined and explained in terms of more general terms (i.e., geometrical shapes like square, triangle, and circle, etc). Furthermore, students were always told that they could ask researchers if they had any questions or could not read or understand any items. 487 forms were received in the data collection of 500 students.

Table 1-

1. On being given a task by the teacher to draw a picture from home using differentgeometrical shapes, I-

  

(a) became happy (b) gets upset (c) gets very upset

2. When my friend got more marks than me in the math test, I-

  

a. becomes happy b. gets upset (c) get sad

6. **Statistical Analysis-** The data collected from 487 students of class III to V were transferred to SPSS software program on the computer. After that, the descriptive analysis and frequency analysis were done first. From these analyses, for the combined male and female data set of the mathematical anxiety scale with **Mean=41.37, Standard Deviation (σ) =7.01**, and **Median=40.00** of the filled data were found as shown in Table 2. There were 250 males and 237 females in the study. The sample consisted of 51.3% of all the participants in the study were males while 48.7% were females as presented in Table 3.

Table 2. Descriptive analysis of the collected data

	N	Mean	Std. Deviation	Median
Anxiety	487	41.37	7.01	40.00
Valid N (listwise)	487			

Table 3. Frequency analysis of the collected data

Valid		Frequency	Valid Percent
	Male	250	51.3
	Female	237	48.7
	Total	487	

On analyzing the data obtained after the pilot study on normal probability curve (NPC), it was observed that data is normally distributed shown in Chart 1. The mean score (M) was obtained at 41.38 and the standard deviation (SD) was found at 7.015. Then, the total mathematical anxiety score is classified into five levels ranging from very high mathematical anxiety to negligible mathematical anxiety whose details are shown in Table 2.

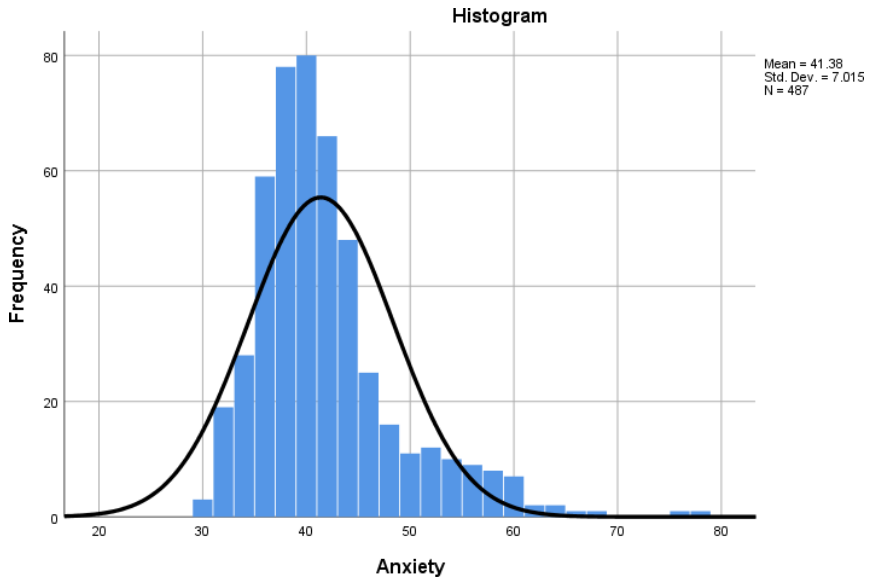

Chart 1. The chart showing the distribution of scores on NPC by SPSS

Level	Levels of Mathematical Anxiety	Score Range
A.	Extremely High Mathematical Anxiety	Above 54
B.	High Mathematical Anxiety	46-54
C.	Moderate Mathematical Anxiety	37-45
D.	Low Mathematical Anxiety	29-36
E.	Negligible Mathematical Anxiety	Below 29

Table 2: Levels of Mathematical Anxiety based on scores obtained

The Cronbach's Alpha Coefficient of MASC was calculated using SPSS version 25 for the evaluation of the internal consistency of the mathematical anxiety scale. The value of the reliability coefficient was determined as 0.728. This coefficient indicatesthat the scale demonstrates a good level of internal consistency and reliability.

Cronbach's Alpha	No. of Items
0.728	28

Reliability Statistics on SPSS Version 25

Conclusion: The Cronbach Alpha coefficient calculated for the evaluation of the internal consistency of the developed mathematical anxiety scale was determined as 0.728 and this value shows that the scale had good reliability. With the results of this study, the scale's content validity was evaluated and it was shown to have acceptable valid features in all.

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