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Development and Validation of Mathematical Anxiety Scale

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Abstract

The aim of this study was to construct and validate a mathematical anxiety test. The test consists of total 18 likert type items with options ranging from Always, Often, Sometime, Rarely and Never. The preliminary instrument consisting of 24 likert type items was tested on 300 students. After the refinement of items using different procedures, only 18 items were selected. The construction and development of the test was done by expert review, preliminary draft, item analysis, selection of items, preparation of final test, norms, validity and reliability of the test. The Cronbach's (α) and split-half reliability of the test as found 0.893 & 0.890 respectively. The intrinsic and criterion validity of the test was found to be 0.944 & 0.740 with satisfactory face, content, discriminant, convergent validity.

Keywords: Construction, Development, Mathematical Anxiety, Reliability and Validity.

Introduction

The existence of anxiety as a basic human emotion has been recognized across cultural boundaries (Bodas & Ollendick, 2005, Engelhard, 2001). Sigmund Freud (1926, 1959) used and developed concept of anxiety. He wrote, "Anxiety, then, is in the first place, something that is felt. We call it an affective state, although we are ignorant of what an affect is. As a feeling, anxiety has a very marked character of unpleasure but not every unpleasure can be called anxiety, for there are other feelings, such as tension, pain or mourning, which have the character of unpleasure. Thus, anxiety must have another distinctive feature. Analysis of anxiety state, thus, reveals that the existences of specific character of unpleasure, act of discharge and perception of these acts is called anxiety" (Edward, 1999).

Anxiety is a strong negative emotion, accompanied by a sense of unease, worry and intrusive thoughts that cannot be put to rest. Anxiety is one of the most pervasive psychological phenomenon of the modem era refers to persistence distressing psychological state arising from an inner conflict. Anxiety is a psychological poison, which can cause as much damage as a physical toxin. An anxiety raises, performance declines, confidence are eroded and ability undermined. Excessive anxiety is extremely unpleasant and completely unhelpful. The anxiety responses ensured that one does the worse. A certain amount of anxiety is normal, useful and necessary. If it is not channeled and put to use, however, it can be debilitating and also contagious (Neylan, 1962**).** Anxiety is a state of uneasiness or tension caused by apprehension of possible future misfortune, danger, worry etc. **(**Collins English Dictionary, 2004). Anxiety is a psychic condition of heightened sensitivity to some perceived threat, risk, peril or danger. It is an emotion characterized by apprehension and anticipation of future danger or misfortune accompanied by feeling of dysphoria or somatic symptoms of tension (American Psychiatric Association, 2000). Anxiety is a displeasing feeling of uneasiness, nervousness, apprehension, fear, concern or worry (Barlow, 2002). Anxiety is complicated psychological situations which have an effect on cognitive, behavioral and psychological states (Putnam, 2010).

Types of Anxiety

According to Psychologists the term Anxiety is divided in three basic categories of Anxiety:

Trait Anxiety

The Anxiety which is relatively stable personality trait is Trait Anxiety in other words a more permanent tendency to be anxious (Scovel, 1978).

State Anxiety

It is a temporary Anxiety; a response to a meticulous Anxiety provoking stimulus such as an important test (Spielberger, 1983).

Situation-specific Anxiety

The Anxiety which refers to the persistent and complicated nature of some anxieties and aroused by an unambiguous type of circumstances or event such as public speaking, examinations or class participations is considered as situation-specific Anxiety (Macintyre and Gardner, 1991).

Mathematical anxiety

Mathematical anxiety has been of great concern for many educators and educational policy-makers because of its adverse effects on students' math's performance and career path. One of the biggest obstructions in mathematical teaching learning process is Mathematics Anxiety. Mathematics Anxiety has been defined as feelings of tension and anxiety which interfere with the manipulation of numbers and solving Mathematical problems in open variety of social life and academic situation. Excessive anxiety results in low self-esteem and poor academic performance (Rapalje, 2006). Math anxiety has most often been explained according to inability to perform math calculations, such as an ability by otherwise intelligent person to cope with quantification, and more generally, mathematics (Perry, 2004). Mathematics anxiety is a state of discomfort that occurs in response to situations involving mathematical tasks that are threatening to self-esteem and the panic, helplessness, paralysis, and mental disorganization arising among some people when they are required to solve a mathematical problem (Bursal & Paznokas, 2006). Mathematics anxiety is feeling of tension, apprehension and fear of situations involving Mathematics and is associated with poor mathematics performance (Ashcraft and Moore, 2009). Mathematics Anxiety is an emotional, mental and physical act related to the Mathematical thinking and problem-solving process and resulting from uncomfortable past experiences related to Mathematics (Arem, 2009).

Mathematics anxiety is loosely regarded as feeling of fear, avoidance and dread when dealing with any situation relating to Mathematics (Zakaria, et. al, 2012). A range of studies suggested that this phenomenon is a highly prevalent problem among students from elementary schools to universities (Betz, 1978; Ma and Xu, 2004; Rodarte-Luna and Sherry, 2008; Jain and Dowson, 2009; Gunderson et al., 2018). The negative math anxiety-performance link has been found in many empirical studies, which indicates MA would lead to poor performance when individuals deal with math reasoning or solve math problems (Bandalos et al., 1995; Ashcraft and Kirk, 2001; Ashcraft, 2002; Cates and Rhymer, 2003; Ma and Xu, 2004; Miller and Bichsel, 2004).

Studies supporting the mathematical anxiety Test

Chiu and Henry (1990) developed Mathematics Anxiety Scale for Children (MASC), a measure based on a shortened version of the Mathematics Anxiety Rating Scale, was developed and administered to 562 children in Grades 4–8. The MASC showed good internal consistency. Evidence for its construct validity included significant relationships with math grades, test anxiety, achievement motivation, and academic ability.

Hopko (2003) gives Confirmatory Factor Analysis of the Math Anxiety Rating Scale–Revised. Using a large sample (N = 815), the construct validity of the revised Math Anxiety Rating Scale (MARS-R) was assessed. The revised measure was applied to the replication sample, with comparable fit indices obtained and excellent generalization across male and female participants.

Internal consistency reliability coefficients of the revised measure were strong, and good convergent and divergent validity was shown with the original MARS-R and other anxiety-related measures.

Zakaria and Nordin (2008) examined the effects of mathematical anxiety on matriculation students as related to motivation and achievement. The study included 88 students of matriculation who were at the end of their second semester of study. The result showed that the mean achievement scores and motivation scores of low, moderate and high anxieties were significantly different.

Bai, et. al. (2009) "Measuring mathematics anxiety: psychometric analysis of a bi-dimensional affective scale". The psychometric properties of 14-item Mathematics Anxiety Scale-Revised (MAS-R) adapted from Betz's (1978) 10-item Mathematics Anxiety Scale were empirically analyzed on a college sample for its internal consistency reliability, parallel-item reliability, and construct validity. In addition, the dimensionality of MAS-R was verified through the two-factor measurement model that fitted to the data significantly better than the one-factor model. Therefore, MAS-R is a psychometrically reliable and valid instrument for measuring bidimensional mathematics anxiety.

Mahmood and Khatoon (2012) constructed Mathematics Anxiety Scale. This anxiety scale consists of 14 statements of 5-point Likert type which is designed to measure the mathematics anxiety of secondary school and senior secondary school students. MAS as a bi-dimensional and shorter instrument in which 7 items are worded positively and 7 items worded negatively, that assess positive and negative dimensions of mathematics anxiety. The range of scores was from 14-70 with and high scores would indicate high mathematics anxiety. MAS has split-half reliability of 0.89.

Devine, et al. (2012) conducted a study on Gender differences in mathematics anxiety and the relation to mathematics performance while controlling for test anxiety. 433 British secondary school children in school years 7, 8 and 10 completed customized mental mathematics tests and MA and TA questionnaires. No gender differences emerged for mathematics performance but levels of MA and TA were higher for girls than for boys. Girls and boys showed a positive correlation between MA and TA and a negative correlation between MA and mathematics performance.

Das, et. al (2014) examined Math anxiety and math achievement in rural minority students. A sample of 222 (103 male and 119 female students) of rural minority students of class VIII were selected randomly. Analyzing the data collected from sample group, the result shows that there is a significant difference between male and female students in math anxiety and math achievement scores. It was also found that math anxiety and math achievement are significantly and inversely correlated ($r = - 0.264$).

Mutawah (2015) investigated the influence of mathematics anxiety in relation to mathematical achievement of middle and high school students. Total 1352 participants from 14 middle and high schools of grades 8, 9, 10 and 11 were selected for the study. The results explored that grade 11 students had the highest mean mathematics anxiety score. The study found negative correlations between the level of mathematics anxiety and students' perceived achievement.

Puteh and Khalin (2016) examined mathematical anxiety and its relationship with the achievement of secondary students in Malaysia. This study aimed to identify mathematics anxiety and its relationship with the achievement of Form Four Students in Perak Tengah district, Malaysia. The design of the study used quantitative method. A total of 190 Form Four students were selected as a research sample. The results showed that the level of mathematics anxiety of the students was at moderate level. There existed no significant difference between the levels of mathematics anxiety of female students compared to the male students. A significant and negative relationship exited between students' achievement and their mathematics anxiety.

Caviola, et. al. (2017). Psychometric properties of the Abbreviated Math Anxiety Scale (AMAS) in Italian primary school children. 1013 primary school students between 8 and 11 years-old were tested. Confirmatory factor analysis showed evidence of the underlying two-factor structure of the Italian version of the AMAS. Results also, demonstrated the invariance of the AMAS across genders.

Surendra, Y. (2018) developed Mathematics Anxiety Scale. The scale consists of 48 items on 5-point scale and the sample was tested on a sample of 240 students. The reliability of the scale is 0.95 on split-half with intrinsic validity 0.97. The duration of the test is fixed 30 minutes.

Yuliani' et. al (2019) are analyzing of mathematics anxiety of junior high school students. The sample of this study was 94 students of junior high school. The results showed that the MA of junior high school students was at a moderate level.

Van Mier, et. al (2019) conducted a study on Gender differences regarding the impact of math anxiety on arithmetic performance in second and fourth graders. Math anxiety and math performance was assessed in 124 second- and fourth-grade children (67 girls and 57 boys). Analyses investigated if math anxiety moderated the effect of gender and grade on math performance revealed significant differences between boys and girls.

Suren and Kandemir (2020) studied the effects of mathematics anxiety and motivation on students' mathematics achievement. The sample of the study consisted of 777 eighth-grade students in a province of Aegean region of Turkey. According to the results of the study, the mathematics anxiety and motivation levels of middle school eighth-grade students were high and there was a positive and moderate relationship between mathematics anxiety and motivation towards mathematics.

From the above studies it is evident that mathematics anxiety affects mathematics achievement, motivation, problem solving ability etc. The mathematics anxiety results in low achievement, low confidence, motivation, fear, failure, depression, tension. Therefore, it is most important variable that needs more and more research in order to help the students to get rid out from the anxiety for their harmonious development.

Methodology

Construction of Mathematical Anxiety Test

A good test is prepared through a systematic process. The process of test development was completed through different steps namely test conceptualization, test construction, item scoring and analysis, reliability and validity and test standardization.

Draft Scale

Mathematical anxiety Scale was standardized on students studying in High schools and in Higher secondary institutes of Jammu and Kashmir. The scale comprised 24 items with 5-point Likert type responses, viz., Always, Often, Sometime, Rarely and Never. This scale was administered to a representative sample of 300 male and female students.

Results

Item analysis

For item analysis, scores of all the 300 students were arranged in ascending order. From this arrangement 27 percent of the subjects from upper and 27 percent subjects from lower group were selected for item analysis. Each group contains 81 students. Discriminative Power was calculated for each item. The value of the Discriminative power is a measure of extent to which a given statement differentiates between low and high groups on that variable.

The results of item analysis for Mathematics Anxiety Scale are presented in the following table.

Table 1. Item analysis of General Mathematics Anxiety

Item No.	Mu	S. D	Ml	S. D	t- value	Decision
1	2.16	1.46	1.29	1.45	4.35	Selected
2	2.24	1.41	2.53	1.34	-1.45	Rejected
3	2.54	1.31	1.77	1.32	3.85	Selected
4	2.54	1.18	1.61	1.46	5.47	Selected
5	2.56	1.27	2.88	1.14	-2.28	Rejected
6	2.29	1.23	1.56	1.35	4.29	Selected
7	2.23	1.12	1.41	1.26	5.85	Selected
8	2.39	1.17	1.74	1.48	3.82	Selected
9	2.71	1.06	1.74	1.53	5.70	Selected
10	2.18	1.17	1.56	1.48	3.64	Selected
11	2.28	1.21	2.28	1.44	0.00	Rejected
12	2.25	1.20	1.32	1.20	6.64	Selected
13	1.87	1.20	1.32	1.34	3.23	Selected
14	2.20	1.42	2.29	1.29	-0.45	Rejected
15	2.17	1.51	1.58	1.47	2.95	Selected
16	2.13	1.28	1.23	1.40	4.50	Selected
17	2.33	1.01	2.51	1.46	-1.05	Rejected
18	2.58	1.17	1.44	1.50	6.70	Selected
19	2.53	1.23	1.81	1.42	4.23	Selected
20	2.29	1.30	1.76	1.38	2.65	Selected
21	2.50	1.31	1.56	1.38	4.70	Selected
22	2.28	1.13	2.29	1.56	-0.05	Rejected
23	2.59	1.14	1.69	1.48	5.29	Selected
24	2.55	1.31	1.37	1.47	5.90	Selected

There were 24 items in the first draft of this scale. Feedback analysis from the participants (n = 300) was used to refine the questionnaire. All the items with t-value less than 2.58 were dropped. Six (6) items failed to meet the criteria. Thus, the final and refined scale comprised of 18 items.

Table 2. Showing dimensions and number of items in respective dimensions

S. No	Dimensions	Item No.	Total
1	Appraisal towards External Stimulus	MAS05, MAS06, MAS07, MAS08, MAS09	5
2	Arousal	MAS01, MAS02, MAS03, MAS04	4
3	Face Expression	MAS10, MAS11, MAS12, MAS13	4
4	Action Tendencies	MAS14, MAS15, MAS16, MAS17, MAS18	5
Mathematical Anxiety Scale			**18**

Scoring

The scoring criterion for items in Mathematical Anxiety scale is given in table 3.

Table 3. Scoring System

GMAS	Always	Often	Sometime	Rarely	Never
Scoring	5	4	3	2	1

Standardization of Mathematical Anxiety Test

The final manuscript with 18 items was administered to a representative sample of 810 secondary school students. The total score of the scale varied from 18 to 90 and can be inferred as higher the score higher the anxiety and vice-versa. The mean age of the students participated in the development of scale was 14 years with 13.9 years as minimum and 18 years as maximum.

Reliability

The consideration of reliability of a scale viewed as essential elements for determining the quality of any standardized test. Cronbach's alpha was used for determining the internal consistency reliability of the scale.

Table 4. Descriptive statistics of Items, Scale and Cronbach's Alpha

Item No.	Descriptive statistics for item				Descriptive statistics for scale		
	Range	Mean	Variance	S. D	Scale Means if item Deleted	*Corrected Item-Correlation	Cronbach's Alpha if Item Deleted
MAS01	4	2.76	1.71	1.30	46.73	.505	.888
MAS02	4	2.73	1.43	1.19	46.76	.582	.886
MAS03	4	2.65	1.70	1.30	46.84	.534	.887
MAS04	4	2.63	1.38	1.17	46.85	.605	.885
MAS05	4	2.91	1.38	1.17	46.57	.603	.885
MAS06	4	2.68	1.28	1.13	46.81	.459	.890
MAS07	4	2.84	1.67	1.29	46.65	.540	.887
MAS08	4	2.81	1.16	1.07	46.68	.448	.890
MAS09	4	2.86	1.30	1.14	46.62	.453	.890
MAS10	4	2.71	1.54	1.24	46.77	.619	.885
MAS11	4	2.76	1.40	1.18	46.72	.518	.888
MAS12	4	2.54	1.41	1.18	46.94	.477	.889
MAS13	4	2.73	1.64	1.28	46.75	.482	.889
MAS14	4	2.55	1.40	1.18	46.94	.472	.889
MAS15	4	2.76	1.76	1.32	46.73	.564	.886
MAS16	4	2.94	1.84	1.35	46.55	.488	.889
MAS17	4	2.63	1.38	1.17	46.86	.613	.885
MAS18	4	2.91	1.38	1.17	46.57	.603	.885

* $r=0.31$ ($p<0.001$) two tailed

Table 5. Descriptive statistics of General Mathematical Anxiety Scale

Mean	Variance	N	S. D	No. of Items
49.50	171.53	810	13.10	18

Validity

Content (Face and logical) Validity

The content (Face and logical) validity of the scale was verified by number of experts and academicians. There are various methods to establish content validity of the tool. Data screening was carried out in order to overcome existence of multicollinearity and singularity in the scale. For testing multicollinearity and singularity 'Determinant' of the R-matrix was estimated and it was greater than in both cases 0.00001. Sampling adequacy was also carried out and found to be greater than 0.50 as required.

Intrinsic Validity

The formula used to determine the intrinsic validity is the square root to its reliability.

Thus, the intrinsic validity of this test is

$$V = \sqrt{R} \qquad V = \sqrt{0.893} \quad V = 0.944$$

Criterion Validity

The criterion validity of mathematical anxiety scale was examined by using Pearson Product Moment Correlation (zero order) with the mathematical anxiety test designed by (Dr. Surender Yadav with n= 120) and was found to be 0.740 ($p<0.001$) two tailed. It confirms that the criterion validity of the mathematical anxiety test is excellent.

Norms

The standard score (more commonly referred to as Z-Score) is very useful statistics, as it enables us to compare scores that are from normal distribution. Standard Scores (Z- score) were calculated by using the descriptive statistics (**Mean = 49.50, SD=13.10, N=810**).

$$Z = (X - \mu) \div \sigma$$

Where X is the raw score of mathematical anxiety scale, μ is the mean and σ is the standard deviation. On the basis of descriptive statistics, the Z -score norms have been prepared which are valid for secondary school students and shown in Table 6.

Table 6. Z-score norms for the Mathematical Anxiety Scale Mean = 49.50 SD: 13.10 N=810

Raw Score	Z-Score	Raw Score	Z-Score	Raw Score	Z-Score
19	-2.32	41	-0.64	63	1.03
20	-2.25	42	-0.57	64	1.10
21	-2.17	43	-0.49	65	1.18
22	-2.09	44	-0.41	66	1.25
23	-2.02	45	-0.34	67	1.33
24	-1.94	46	-0.26	68	1.41
25	-1.87	47	-0.19	69	1.48
26	-1.79	48	-0.11	70	1.56
27	-1.71	49	-0.03	71	1.64
28	-1.64	50	0.03	72	1.71
29	-1.56	51	0.11	73	1.79
30	-1.48	52	0.19	74	1.87

Raw Score	Z-Score	Raw Score	Z-Score	Raw Score	Z-Score
31	-1.41	53	0.26	75	1.94
32	-1.33	54	0.34	76	2.02
33	-1.25	55	0.41	77	2.09
34	-1.18	56	0.49	78	2.17
35	-1.10	57	0.57	79	2.25
36	-1.03	58	0.64	80	2.32
37	-0.95	59	0.72	81	2.40
38	-0.87	60	0.80	82	2.48
39	-0.80	61	0.87	83	2.55
40	-0.72	62	0.95	84	2.63

The Z- score norms have been categorised labelled and interpretation in reference to practice of Prayer are given in Table 7.

Table 7. Classification of Norms for Interpretation of the Mathematical Anxiety Scale

S. No	Range	Level	Mathematical Anxiety
1	1.50 and above	A	Extremely High
2	+0.51 to +1.49	B	High (Positive)
3	-0.50 to + 0.50	C	Average/Moderate/Neutral
4	-1.49 to – 0.51	D	Low (Negative)
5	-1.50 and below	E	Extremely Low

Conclusion

The Mathematical Anxiety Scale or test has excellent internal consistency, split-half reliability (Guttman) and followed by the use of Spearman-Brown prophecy formula. The face, content, intrinsic and criterion validities were also high and are in acceptable range. Thus, it can be concluded that the scale is highly reliable and valid for measurement of mathematical anxiety of 13 and above years of age group.

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