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Validation of Abbreviated Science Anxiety Scale in the Indian Context

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Abstract: ***The abbreviated science anxiety scale[1] was validated in the Indian context with 290 secondary school students of grade 8 as the sample subjects. Exploratory factor analysis revealed the original two factors explaining 54.778 % of total variance in science anxity construct. Confirmatory factor analysis validated the factor structure of the construct with excellent goodness of fit estimates like CMIN/DF = 1.830, CFI = 0.969, TLI = 0.957, RMSEA = 0.054 and SRMR = 0.0392, conducted using the estimator maximum likelihood (ML). The floor and ceiling effect estimation for content validity showed that both the effects are absent with estimates way lesser than the benchmark of 15 % at 6.55 % and 0 % respectively. The internal consistency reliability estimation using Cronbach's alpha found that the five items of the first factor "Learning science anxiety" and four items of the second factor "Science evaluation anxiety" had this estimate at 0.803 and 0.678 respectively, both of which fairly indicate good measurement of reliability of the scale. The education implications of the study are discussed.***

Keywords: Science Anxiety, Indian Secondary School Students, Exploratory Factor Analysis, Confirmatory Factor Analysis, Cronbach's Alpha Internal Consistency Reliability, Floor and Ceiling Effects.

1. INTRODUCTION

The seminal works of Pekrun[2-4] on academic emotions and their regulation strategies established the role of various classroom related academic emotions on the performance of the students in the literature. One of the prominent and potent academic emotions which undesirably play out in the classroom is the subject related anxiety in the students[5]. In the context of STEM education and specifically in the field of science education, the academic parallel of this variable is science anxiety. It is defined as "a debilitating combination of fearful negative emotion and cognition in the context of science learning"[6]. A recent study

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conducted in 2021[7] on Indian secondary school students of 12th grade from all streams, found that anxiety coupled with depression was more in science stream students in comparison to non-science stream students. The genesis of the undesirable psychological trait of science anxiety begins years before the student reaches in 12th grade. The secondary school students in India require to qualify a Board Examination at 10th grade, which is conducted both at federal and state levels, and depending upon the affiliation of the school, either to the federal board or the state board, the student needs to appear and qualify the same for ensuring further academic journey, involving specialization either in science arts or science stream[8]. The preparation for this board examination of 10th grade commences typically from 8th standard onwards.

Any research enterprise addressing the pervasive issue of science anxiety in Indian secondary school students would require the presence of a robust tool which strong psychometric properties. The scale's validity would gain further traction when it is brief and cross-validated in multiple cultures. To address this pertinent research gap, the present study adapted the abbreviated science anxiety scale[1] in the Indian context.

2. METHODOLOGY

Participants

The subjects of the sample comprised of 290 students of 8th grade from the Army Public School (APS), Jalandhar Cantonment, from the Indian State of Punjab.

Procedure

The investigator conducted this cross-sectional descriptive design study as part of an action research, which itself was one of the several activities she was required to perform, besides teaching, during her semester long teaching internship in the mentioned school. The school authorities provided the formal permission to conduct such study on their students. Before administering the study, the purpose of the study, anonymity of the data gathered of the sample subjects and their consent to be part of the work was taken verbally during her regular teaching sessions supervised by an in-service teacher of the school. The students of the study were selected using purposive sampling in this study from multiple sections of grade 8.

Instrument

The scale adapted in the present study was itself adapted from the Abbreviated Math Anxiety Scale (m-AMAS) [9]. It has two factors, namely, the Learning science anxiety measured with five items and the Science evaluation anxiety comprised of the remaining four items of the scale. The responses of the students on how much anxiety they experienced on nine specific activities related to science learning and evaluation are registered on a five point Likert scale where 1=low anxiety and 5=high anxiety. The statements of the nine items are seen in Table 1.1.

Table 1.1 Nine Items of Abbreviated Science Anxiety Scale

S.No.	Factor	Item Statement
1	"Learning	"Being given science homework with lots of difficult questions that

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	Science Anxiety"	you have to hand in the next day"
2		"Listening to the teacher talk for a long time in science"
3		"Listening to another child in your class explain a science problem"
4		"Watching the teacher work out a science experiment on the board"
5		"Starting a new topic in science"
6	"Science Evaluation Anxiety"	"Having to complete a worksheet in science by yourself"
7		"Thinking about a science test the day before you take it"
8		"Finding out that you are going to have a surprise science quiz when you start your science lesson"
9		"Taking a science test"

3. RESULTS

Descriptive Statistics

The measures of centrality tendency, dispersion and symmetry in the form of mean, standard deviation, skewness and kurtosis are seen in Table 1.2 and Table 1.3

Table 1.2 Descriptive Statistics of the Items of Science Anxiety Scale

Item No.	Mean	Standard Deviation	Skewness	Kurtosis
1	1.98	1.218	0.993	-0.074
2	2.50	1.212	0.321	0.739
3	2.84	1.359	0.076	-1.089
4	2.56	1.170	0.179	-0.704
5	2.99	1.424	-0.005	-1.270
6	2.14	1.329	0.911	-0.410
7	2.19	1.378	0.774	-0.726
8	1.85	1.206	1.169	0.172
9	1.57	0.972	1.696	2.295

Table 1.3 Correlation Matrix of the Items of Science Anxiety Scale

		LSA 1	LSA 2	LSA 3	LSA 4	LSA 5	SEA 6	SEA 7	SEA 8	SEA 9
Correlation	LSA 1	1.000	.390	.489	.361	.497	.333	.342	.342	.356
	LSA 2		1.000	.466	.468	.437	.421	.320	.269	.366
	LSA 3			1.000	.496	.462	.320	.154	.254	.267
	LSA 4				1.000	.432	.309	.278	.174	.349
	LSA 5					1.000	.343	.289	.261	.308

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	SEA 6						1.000	.367	.321	.437
	SEA 7							1.000	.290	.371
	SEA 8								1.000	.344
	SEA 9									1.000

3.1.1 Floor and Ceiling Effects of Content Validity Estimation

Table 1.4 Floor and Ceiling Effects of the Items of Science Anxiety Scale

S.No.	No. of Subjects with Lowest Score of the Scale of 9	No. of Subjects with Highest Score of of the Scale 45	Total Subjects	Floor Effect Estimate	Ceiling Effect Estimate	Benchmark of Acceptance	Result	Remark on Item Floor or Ceiling Effect
1	19	0	290	6.55%	0 %	15%	Both Floor and Ceiling effects estimates are less than the benchmark	Absent

The percentages of total 290 subjects having the lowest score of 9 and the highest score of 45 of the scale were estimated and found to be at 6.55 % and 0 % respectively, which are way below the benchmark of 15 % [10]. These results establish the content validity of the scale.

3.1.2 Factors Extraction Using Exploratory Factor Analysis (EFA)

Table 1.5 Estimation of the Determinant of Science Anxiety Scale

		LSA 1	LSA 2	LSA 3	LSA 4	LSA 5	SEA 6	SEA 7	SEA 8	SEA 9
Correlation	LSA 1	1.000	.390	.489	.361	.497	.333	.342	.342	.356
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	LSA 3	.489	.466	1.000	.496	.462	.320	.154	.254	.267
	LSA 4	.361	.468	.496	1.000	.432	.309	.278	.174	.349
	LSA 5	.497	.437	.462	.432	1.000	.343	.289	.261	.308
	SEA 6	.333	.421	.320	.309	.343	1.000	.367	.321	.437
	SEA 7	.342	.320	.154	.278	.289	.367	1.000	.290	.371
	SEA 8	.342	.269	.254	.174	.261	.321	.290	1.000	.344
	SEA 9	.356	.366	.267	.349	.308	.437	.371	.344	1.000
Sig. (1-tailed)	LSA 1		.000	.000	.000	.000	.000	.000	.000	.000
	LSA 2	.000		.000	.000	.000	.000	.000	.000	.000
	LSA 3	.000	.000		.000	.000	.000	.004	.000	.000
	LSA 4	.000	.000	.000		.000	.000	.000	.001	.000
	LSA 5	.000	.000	.000	.000		.000	.000	.000	.000
	SEA 6	.000	.000	.000	.000	.000		.000	.000	.000
	SEA 7	.000	.000	.004	.000	.000	.000		.000	.000
	SEA 8	.000	.000	.000	.001	.000	.000	.000		.000
	SEA 9	.000	.000	.000	.000	.000	.000	.000	.000	

Determinant = .080

Table 1.6 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.872**
Bartlett's Test of Sphericity	Approx. Chi-Square	721.066
	df	36
	Sig.	.000

Table 1.7 Total Variance Explained

Component	**Extraction Sums of Squared Loadings**	**Rotation Sums of Squared**

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				Loadings[a]
	Total	% of Variance	Cumulative %	Total
1	3.846	42.729	42.729	3.349
2	1.084	12.050	54.778	2.898

Extraction Method: Principal Component Analysis

Table 1.8 Pattern Matrixaa

	Component	
	1	2
LSA3	.896	
LSA4	.772	
LSA5	.714	
LSA2	.620	
LSA1	.571	
SEA7		.765
SEA8		.695
SEA9		.695
SEA6		.626

Extraction Method: Principal Component Analysis. Rotation Method: Oblimin with Kaiser Normalization. A

Table 1.9 Reliability Statistics of Learning Science Anxiety Factor

Cronbach's Alpha	**N of Items**
.803	5

Table 1.10 Reliability Statistics of Science Evaluation Anxiety Factor

Cronbach's Alpha	**N of Items**
.678	4

The exploratory factor analysis was conducted using SPSS Statistics Ver. 23.0 on the sample size of 290 using Principal Component Analysis (PCA) extraction method under direct oblimin rotation, for a threshold inter item correlation fixed at 0.32. The determinant obtained was 0.08 which was way higher than the benchmark of 0.00001 indicating that the quality of the data was good enough to go ahead with the further analysis of factor extraction (see Table 1.5). Also, the Keiser Meyer Olkin sampling adequacy estimate was high enough at 0.872 above the benchmark of 0.6 indicating the sample size collected for the present study to be sufficient, along with a desirably significant Barlett's test of sphericity result (see Table 1.6). Two factors were extracted akin to the original study, which together explained 54.778 % of total variance in the construct (see Table 1.7). The first factor had the initial five items and the second factor had the remaining four items with factor loadings ranging from 0.571 to 0.896 (see Table 1.8). The reliability estimation was conducted by finding the internal consistency reliability of the items of first and second factors, which were found to be acceptable at 0.803 and 0.678 respectively (see Table 1.9 and Table 1.10).

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3.1.3 Estimation of Construct Validity of the Factor Structure of Abbreviated Science Anxiety Scale using Confirmatory Factor Analysis (CFA)

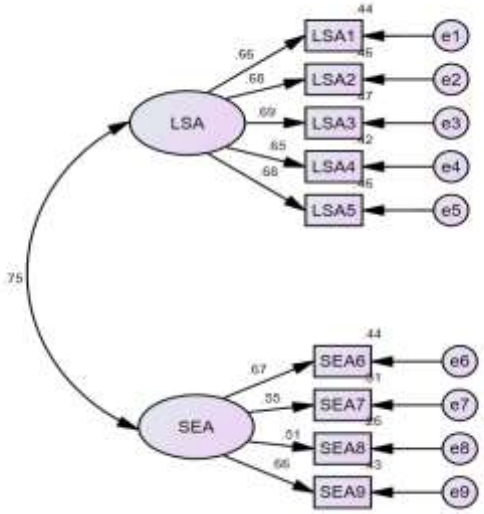

Figure 1.1 Path Diagram of the Factor Structure of Science Anxiety Construct in Indian Secondary School Students.

Table 1.11 Goodness of Fit Estimates of Abbreviated Science Anxiety Scale

Estimand	CMIN/DF	CFI	TLI	RMSEA	SRMR
Benchmark	< 3	>0.95	>0.95	<0.05	0.08
Estimates	1.83	0.969	0.957	0.054	0.0392

The path diagram of the factor structure of the abbreviated science anxiety scale displayed to inter-related factors of the construct associated with learning and evaluation of science in the secondary students with the correlation coefficient high at 0.77 (see Figure 1.1). Also the items loaded very highly and precisely on their respective factors only. The goodness of fit estimates were excellent with CMIN/Df less than 3 at 1.83, both CFI and TLI greater than 0.95 at 0.969 and 0.957 respectively, SRMR less than 0.08 at 0.0392 and RMSEA slightly higher than its benchmark of 0.05 at 0.054 as per [11] (see Table 1.11).

3.1.4 Estimation of Convergent and Divergent Validities of Abbreviated Science Anxiety Scale

Table 1.12 Estimation of Composite Reliability, Average Variance Explained and Item-Total Correlation of the Abbreviated Science Anxiety Scale.

	Factor Loading	SMC	1-SMC	CR	AVE	Square root of AVE	Item- Total Correlation
Item1	0.66	0.436	0.564	0.805	0.452	0.672	0.602
Item2	0.68	0.462	0.538				0.604
Item3	0.69	0.476	0.524				0.554

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Item4	0.65	0.423	0.578				0.548
Item5	0.68	0.462	0.538				0.581
Item6	0.67	0.449	0.551	0.691	0.362	0.601	0.538
Item7	0.55	0.303	0.698				0.445
Item8	0.51	0.26	0.74				0.418
Item9	0.66	0.436	0.564				0.53

The composite reliability of the first factor "Learning Science Anxiety" was 0.805, which is greater than the benchmark of 0.6 and its average variance explained is at 0.452 which is lesser than the benchmark of 0.5. The composite reliability of the second factor "Science Evaluation Anxiety" was 0.691, which is greater than the benchmark of 0.6 and its average variance explained is at 0.362 which is lesser than the benchmark of 0.5 [12]. Also, the square root of the average variance explained for the two factors are 0.672 and 0.601 respectively, lesser than the correlation coefficient between the factors of 0.77. These results indicated that there is scope of improvement for the convergent and divergent validities of the scale. The item-total correlation of the nine items ranged from 0.53 to 0.604 higher than the benchmark of 0.3 to indicate content validity [13-17] (see Table 1.12). Using the values obtained in Table 1.3, the Heterotrait-Monotrait HTMT test of discriminant validity was conducted, and its estimate was found to be at 0.758, which is lesser than the benchmark of 0.85 or 0.9 [18], indicating the presence of divergent validity of the scale in this study.

4. DISCUSSION

The seriousness of the science anxiety related issues is contextualized from that fact that India is a young nation and its youth requires source of employment at their disposal to lead a quality life. There are a lot of employment opportunities in STEM related professions and the demand of quality STEM professionals by the industry can be met when there is a supply of quality students from the school to the colleges and universities for graduation into the job market. Such a logistics cannot get manifested until science stream students with high science self-efficacy can be developed from upper primary and secondary levels of school education system in the country.

Unrealistic parental pressure, lower recruitment of quality science teachers in school institutions and poor perception of science as a subject among the young adolescents owing to the presence of higher level of science anxiety levels in them, are some of the serious challenges which require immediate addressing through scientific approach of research.

Trading on these lines, the present study tried to adapt a brief, robust and a cross-cultural tool to measure science anxiety scale among secondary school students of India. The tool was found to extract the same two factors namely Learning science anxiety and Science evaluation anxiety with the nine items of the scale loading highly on their respective factors, with excellent content, construct and discriminant validities and acceptable reliability estimates in the form of Cronback alpha and composite reliability. However, the scale's convergent validity can improve.

Considering the prevalence of science anxiety levels among secondary school students of India, the teaching practitioners can take cognizance of this state of affair and indulge in

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quality research of science education in their classrooms so as to pave way for the development of intervention programs in the curriculum to reduce the fear and its associated emotions during the learning and evaluation of science.

5. CONCLUSION

It is hoped that the availability of a validated cross-cultural scale would not only help in the progression of the research of science education in the country, but also would aid in compare and contrast of results of this vital construct of science education across multiple countries.

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20. ABBREVIATIONS
21. EFA – Exploratory Factor Analysis
22. CFA – Confirmatory Factor Analysis
23. AVE – Average Variance Explained
24. CR- Composite Reliability
25. HTMT – Heterotrait-Monotrait
26. m-AMAS - Abbreviated Math Anxiety Scale
27. APS – Army Public School
28. CMIN/Df – Chi-square by Degrees of Freedom
29. CFI – Comparative Fit Index
30. TLI – Tucker Lewis Index
31. RMSEA – Root mean square error of approximation
32. SRMR – Standard Root Mean Square
33. STEM – Science Technology Engineering Mathematics