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Construction and Standardization of Science Anxiety Scale

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Abstract: *This paper highlights the process of construction and standardization of a tool to assess science anxiety of students lying in age group of 13-18 years. Given poor teaching techniques, lack of appropriate role models, and societal prejudices in relation to science, the baggage of science anxiety can be perceived as both cognitive and emotional. To overcome the same, science anxiety scale can be used by students as a tool to determine from where their anxiety regarding science comes from. In the same row, it can be used as a tool by the teacher to diagnose their greatest hurdle in improving literacy of their students with respect to subject science. While developing such a significant scale, the researcher went through numerous scales and questionnaires developed to screen different anxiety scales, and eventually came up with first draft of science anxiety scale comprising of 50 items. After review and evaluation by subject experts, the number of items reduced to 38 in second draft and eventually to 31 in final draft after conducting item analysis. The reliability coefficient of the science anxiety scale (as computed by test-retest method) was computed to be 0.90. As far as validity is concerned, the content validity was established for the science anxiety scale in the process of its construction itself as this scale was given individually to some experts for review of items, and their suggestions were sought and complied with, as to whether each item appropriately matched the content area and objectives specified. Present research work concludes by discussing educational implications and suggestions for future research.*

1. INTRODUCTION

Research related to effective teaching and learning of science can dwell into investigation of cognitive processes as well as affective factors (Sahin, Caliskan, & Dilek, 2015). However, Pintrich, Marx and Boyle (1993) as well as Randler et al. (2011) made an observation that in general individual's affective characteristics such as intentions, goals, experiences, and emotions are paid considerably less attention. Nevertheless, emotions have an important role to play in science learning. One emotional dimension of the affective factors that has received increasing attention in recent past is anxiety (Sahin, Caliskan, & Dilek, 2015). Infact, anxiety is one of the popular areas of research for educators as well as psychologists.

Interesting aspect about anxiety is that it may serve to motivate as well as exercise greatest adverse effects on the process of thinking and problem solving that the educator is trying to enhance (Kaya & Yildirim, 2014). On extrapolating concept of anxiety in domain of subject science, one is bound to witness ample reports with respect to declining achievement scores in science (Rakow, Welch, & Hueftle, 1984; Rotberg, 1984; Coleman, 1985), reduced time allocated for science instruction (Mechling & Oliver, 1983; Cawelti & Adkisson, 1985), fewer women enrolled in science classes (Matyas, 1985), and negative student attitudes toward science increasing by grade level (Yager & Yager, 1985). Such reports serve as evidence that suggests a relationship among these factors and the existence of science anxiety (Chiarelott & Czerniak, 1987). Furthermore, vast research in the area of math anxiety serves as clarion call to reveal a similar phenomenon in the study of science that goes by the name of science anxiety (Czerniak & Chiarelott, 1984).

Science anxiety is a fear or aversion toward science concepts, scientists, and/or science-related activities (Mallow, 1981). As per Mallow (1987), science anxiety is a debilitating interaction of emotion (fear) with cognition (science learning). This assertion is supported by Udo, Ramsey, Reynolds-Alpert and Mallow (2001) who proposed that there is a correlation between students' feelings and their ability to understand the subject matter. Distinct from general test/performance anxiety, science anxiety often manifests itself as a crippling panic on examinations in science classes (Alvaro, 1978). As such, students suffering from science anxiety tend to be calm and productive in

their non-science courses, including their mathematics courses, thereby making sense that science anxiety and math anxiety are two different phenomenons (Mallow, 2010; Kaya & Yildirim, 2014). In support of this assertion, Anderson and Clawson (1992) stated that students who have science anxiety may be doing well in all their other courses, including math, but are so anxious about science courses that they are unable to function effectively in latter. This anxiety with respect to science courses eventually results in panic during science exams and subsequently poor performance in science.

Given the above stated phenomenon of science anxiety, concept of science anxiety scale holds significance. Science anxiety scale as a tool can be used by students to determine from where their anxiety regarding science comes from. In the same row, it can be used as a tool by the teacher to diagnose their greatest hurdle in improving literacy of their students with respect to subject science. Teachers can use it to determine students' level of science anxiety in a particular course for instructional purposes or as a pre-test and post-test to determine the change in level of students' science anxiety.

Above mentioned significance of science anxiety scale led the researcher to develop a valid and reliable instrument to measure science anxiety of children lying in the age group of 13-18 years. As a start up step, researcher did an extensive literature review on studies concerning anxiety in the process of education and instruction, as well as causes and results of effect of anxiety on an individual's physical state, psychological state and eventually learning. Scales developed for assessing science anxiety (Alvaro, 1978; Chiarelott & Czerniak, 1987; Mallow, 1994; Bowen, 1999; Bursal, 2008; Guzeller & Dogru, 2012), math anxiety (Richardson & Suinn, 1972; Fennema & Sherman, 1976; Wigfield & Meece, 1988; Alexander & Martray, 1989; Hopko, Mahadevan, Bare, & Hunt, 2003; Bintaş, 2008), computer and internet anxiety (Wang, 2007), physical activity and sport anxiety (Norton, Hope, & Weeks, 2004), test anxiety (Cassady & Johnson, 2002; Driscoll, 2007; Spielberger, 2010), state-trait anxiety (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) were examined carefully.

After doing a thorough scan of above mentioned tools (all constructed in foreign countries), the researcher took a significant step forward to scientifically develop a science anxiety scale that can be comfortably and aptly put to use in educational settings. The process of development of science anxiety scale involved following steps:

(i) *Planning of the Scale:* Planning of the science anxiety scale encompassed all the operations that go into production of any scale. For instance, it included fixing up the objectives/purposes; determining the weight age to be given to different instructional objectives; taking decisions regarding mechanical aspects like number of items, time duration, administration procedure, marking scheme, etc.; and preparation of blueprint.

(ii) *Writing and Editing of the Items:* To measure science anxiety of students, 50 items were written after going through the conceptual framework of science anxiety. All the items were carefully worded for use with children lying in age group of 13-18 yrs. The following points were kept in mind while writing items of the scale:

(a) The test items should be clear, comprehensive and free from ambiguity.

(b) The language of the items should be so chosen that the content and not the form of the items determine the answer.

(c) The vocabulary used in the items should be simple enough to be understood by all respondents.

Construction of the Scale: On the basis of available literature on science anxiety, scale to measure science anxiety was constructed by the investigator, taking valuable tips from teachers as well as students. The construction phase of science anxiety scale was based on three stages: (a) First draft of science anxiety scale, (b) Second draft of science anxiety scale, (c) Final draft of science anxiety scale.

2. FIRST DRAFT OF SCIENCE ANXIETY SCALE

At this stage, the investigator prepared the items for the scale, directions for administration of scale, directions for responding to scale, and directions for scoring the scale. Thus, a first draft of science anxiety scale with 50 items was prepared by the investigator, for use with children lying in the age group of 13-18 yrs. The items were constructed

as rating scale type in which students' responses were to lie on five point scale as 'strongly agree', 'agree', 'undecided', 'disagree', and 'strongly disagree'. The items intended to measure science anxiety were formulated as either positive or negative statements. To find the overall science anxiety score of a subject, the total selected points must be added, as each response option, i.e. 'strongly agree', 'agree', 'undecided', 'disagree', and 'strongly disagree' have respective weight of 1, 2, 3, 4, and 5 for positive items, and 5, 4, 3, 2, and 1 for negative items. The distribution of positive and negative items for the first draft of science anxiety scale has been given in table 1.

Table 1: *Distribution of positive and negative items for the first draft of science anxiety scale*

Statements	Item Number	Total
Positive Items (+)	3, 4, 6, 9, 10, 13, 14, 15, 17, 18, 20, 21, 22, 40, 41, 43, 44, 46, 47, 48, 49	21
Negative Items (-)	1, 2, 5, 7, 8, 11, 12, 16, 19, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 42, 45, 50	29
Total		**50**

Table 1 shows that out of 50 items of the first draft of science anxiety scale, 21 were positive and 29 were negative items.

First Try-out and Evaluation: The first draft consisting of 50 items was given to esteemed supervisor and other experts in university for their valuable opinion. Items that seemed repetitive or ambiguous were eliminated or suitably modified after heeding to their valuable judgment. Henceforth, 12 items were dropped and 4 items were modified as shown in table 2.

Table 2: *Distribution of items dropped or modified from the first draft of science anxiety scale*

S. No.	Item Number	f	Remarks
1	3, 8, 10, 24, 31, 32, 33, 34, 36, 39, 42, 45	12	Dropped
2	1, 7, 21, 25	4	Modified

Table 2 shows that 12 items were dropped while 4 items were modified after consultation with supervisor and other experts. Thus, in total 38 items were retained in the second draft of science anxiety scale.

Second Draft of Science Anxiety Scale

After the referred changes in first draft, the second draft of science anxiety scale consisted of 38 items. The distribution of positive and negative items for the second draft of science anxiety scale has been given in table 3.

Table 3: *Distribution of positive and negative items for the second draft of science anxiety scale*

Statements	Item Number	Total
Positive Items (+)	3, 5, 7, 10, 11, 12, 14, 15, 17, 18, 19, 30, 31, 32, 33, 34, 35, 36, 37	19
Negative Items (-)	1, 2, 4, 6, 8, 9, 13, 16, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 38	19
Total		**38**

Table 3 shows that out of 38 items of the second draft of science anxiety scale, 19 were positive and 19 were negative items.

Second Try-out and Evaluation: This second try-out was intended to do item analysis. As such, the second draft of science anxiety scale, consisting of 38 items, was administered to a group of 52 students of 9th class of Government Model Senior Secondary School, Modern Housing Complex, Manimajra. The purpose of administration of scale was explained to the students and all the instructions regarding their marking of responses was made clear. The respondents were asked to give only one response for each statement and not to leave any statement unanswered. It was also made clear that there is no right or wrong answer to the referred statements. Infect, it is just about how the particular respondent think, feel or behave in relation to work related with science. After collecting the filled sheets of respondents, the investigator did the scoring as per decided scheme. On the basis of total score of each respondent, high and low groups were formulated according to Kelley criteria of taking up top 27% and bottom 27% as high and low groups respectively. After that, t-test was computed between high and low group scores with respect to each item as shown in table 4

Table 4: *t-ratio of the items of the second draft of science anxiety scale*

Item No.	t-ratio	Item No.	t-ratio	Item No.	t-ratio
1	2.63*	14	2.39*	27	3.13**
2	4.13**	15	4.94**	28	1.69
3	2.33*	16	2.82**	29	5.06**
4	2.15*	17	2.88**	30	2.28*
5	3.56**	18	3.51**	31	3.61**
6	3.28**	19	2.91**	32	2.65*
7	3.71**	20	1.08	33	4.54**
8	1.34	21	0.78	34	3.23**
9	2.89**	22	0.74	35	3.35**
10	2.90**	23	3.22**	36	2.58*
11	5.63**	24	3.17**	37	3.11**
12	2.34*	25	1.28	38	2.96**
13	3.73**	26	0.38		

** Significant at 0.05 level* *** Significant at 0.01 level*

(Critical Value 2.06 at 0.05 and 2.78 at 0.01 level, df=26)

Table 4 shows that the t-ratios for 7 items, i.e. 8, 20, 21, 22, 25, 26 and 28 were not significant even at 0.05 level of significance, while rest of the 31 items were significant either at 0.05 or 0.01 level of significance. Henceforth, distribution of dropped 7 items and retained 31 items for the final draft has been given in table 5.

Table 5: *Distribution of items selected or rejected for the final draft of science anxiety scale*

S. No.	Item Number	f	Remarks
1	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 23, 24, 27, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38	31	Selected
2	8, 20, 21, 22, 25, 26, 28	7	Rejected

Table 5 shows that 7 items were dropped and 31 items were retained for the final draft of science anxiety scale.

3. FINAL DRAFT OF SCIENCE ANXIETY SCALE

The final draft of science anxiety scale was yielded on the basis of changes in second draft. The referred final draft consisted of 31 items, in total. The distribution of positive and negative items for the final draft of science anxiety scale has been given in table 6.

Table 6: *Distribution of positive and negative items for the final draft of science anxiety scale*

Statements	Item Number	Total
Positive Items (+)	3, 5, 7, 9, 10, 11, 13, 14, 16, 17, 18, 23, 24, 25, 26, 27, 28, 29, 30	19
Negative Items (-)	1, 2, 4, 6, 8, 12, 15, 19, 20, 21, 22, 31	12
Total		**31**

Table 6 shows that out of 31 items of the final draft of science anxiety scale, 19 were positive and 12 were negative items.

4. SCORING

The items of science anxiety scale have been constructed as rating scale type in which students' responses were to lie on five point scale as 'strongly agree', 'agree', 'undecided', 'disagree', and 'strongly disagree'. The items intended to measure science anxiety have been formulated as either positive or negative statements. To find the overall science anxiety score of a subject, the total selected points must be added, as each response option, i.e. 'strongly agree', 'agree', 'undecided', 'disagree', and 'strongly disagree' have respective weight of 1, 2, 3, 4, and 5 for positive items, and 5, 4, 3, 2, and 1 for negative items. The scoring pattern of science anxiety scale has been presented in table 7.

Table 7: *Scoring pattern for each item of science anxiety scale*

Items	**Score Assigned**				
	Strongly Agree	*Agree*	*Undecided*	*Disagree*	*Strongly Disagree*
Positive (+)	1	2	3	4	5
Negative (-)	5	4	3	2	1

Table 7 shows that the sum of scores on positive items yields the total positive score. Similarly, sum of scores on negative items yields the total negative score. Final sum of total positive and negative score gives the composite score for science anxiety of an individual. The maximum possible science anxiety score can be 155 and minimum possible science anxiety score can be 31 for a subject attempting this science anxiety scale.

5. RELIABILITY

Reliability is often measured with reliability coefficient. In the present case, the reliability coefficient of the science anxiety scale was calculated by test-retest method. For the same, the scale was initially administered to a sample of 46 students of class IX drawn from Government Model High School, Sector-25, Chandigarh. The same science anxiety scale was administered to the same sample of students after a gap of two weeks. The product moment coefficient of correlation for the two scores was computed, which was found to be 0.90. This coefficient of correlation is fairly high, which in turn testifies the reliability of the science anxiety scale.

6. VALIDITY

In the present case, the content validity was established for the science anxiety scale in the process of its construction itself. The content validity is concerned with the relevance of the items' content individually and as a whole. In this very context, Anastasi (1955) stated that "content validity involves essentially the systematic examination of the test content to determine whether it covers a representative sample of the behavior domain to be measured". As such, content validity, as suggested in the referred form, of the science anxiety scale, was examined on the basis of the judgment by experts. Since, this scale was given individually to some experts for review of items, and their suggestions were sought and complied with, as to whether each item appropriately matched the content area and objectives specified; hence the content validity of the science anxiety scale can be said to be ascertained.

7. IMPLICATIONS

Given poor teaching techniques, lack of appropriate role models, and societal prejudices in relation to science, the baggage of science anxiety can be perceived as both cognitive and emotional (Mallow, 2006). By using the above detailed science anxiety scale, science anxiety of students lying in age group of 13-18 years can be revealed. Thereafter, if high level of science anxiety is detected, teacher can deliberately use this diagnosis to improve literacy of their students with respect to subject science. Furthermore, science anxiety scale can prove to be of great significance to researchers as well as academic counselors, whereby former can use it as a variable to explore its relationship with various learning strategies as well as other significant constructs, and latter can use it to determine which style of instruction best fits the student depending on his/her science anxiety level. This can be regarded as one of the important steps toward improvement of science education for the coming generations.

Finally, further research on the validation and refinement of this science anxiety scale is strongly suggested. Particularly, investigations can be carried out across different populations and settings to establish construct validation.

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