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Construct Validity and Reliability of Attitude towards Science Scale

Chandni Laroiya

Dr. Sanjeev Kumar

Abstract
The present study deals with the development of Attitude towards Science Scale based on TOSRA (Test of science-related attitudes) and anxiety towards science. The study was conducted on students belonging to age group of 14-15 years from government schools of Chandigarh, India. The validity of scale was established using exploratory factor analysis and the final factor structure was confirmed using confirmatory factor analysis. After content validity of scale 42 items were subjected to principal axis factoring which revealed 5 factors with total variance explained of 78%. These dimensions were identified as Anxiety towards science, enjoyment of science lessons, adoption of scientific attitudes, enjoyment of science lessons and social implications of science. In order to further confirm the theoretical model of five factors confirmatory factor analysis was used.Cronbach Alpha was used to determine reliability of the test which was found to be 0.92.

Keywords- Attitude towards science, exploratory factor analysis, confirmatory factor analysis, anxiety towards science.

Author Correspondence:
Chandni Laroiya
Research Scholar
Department of Education, Panjab University
Chandigarh, India
Email ID- chandnilaroiya6@gmail.com

1.Introduction

The importance of affective attitudes in science has been widely accepted for the past many years. These attitudes have been known to be contributors in developing socially responsible citizens (Bybee & McCrae, 2011) who possess a willingness to perform better in science (Beaton, Martin, Mullis, Gonzalez, Smith, & Kelley, 1996). Science educators have also correlated positive attitudes with higher levels of motivation and persistence to obtain subject mastery. Attitudes are both products and facilitators of student learning; hence they should be measured sensitively. There are different perspectives which exist when it comes to measuring attitudes. Few proponents regard it as multidimensional construct with three distinct domains of affect, behavior, and cognition (Krech, Crutchfield, & Ballachey, 1962), corresponding to enjoyment, behavioral readiness and one's beliefs about the object respectively. The other theoretical perspective regards attitude as a unidimensional concept solely related to the affective domain (Fishbein & Ajzen, 1975) and the cognitive component is regarded to be a part of one's beliefs which have been kept separately from attitude.

This distinction of attitudes as components of the affective domain has been contributed by many psychologists and has been implemented in the current research paper. Klopfer (1971) contrasts attitude towards science as predispositions of affective domain into a series of attitudes; (1) science and scientists, (2) attitude to inquiry, (3) adoption of scientific attitudes, (4) enjoyment of science learning experiences, (5) interest in science learning experiences, and (6) interest in a career in science. Many tools have been constructed based on these dimensions and the most widely used, adapted, translated and modified tool is the TOSRA- Test of Science Related Attitudes, developed by Fraser (1978, 1981).Although TOSRA still finds its applications and with advent of new-age issues, it becomes a necessity to address other relevant dimensions such as science anxiety which are in cognizance with today's challenges of negative experiences and beliefs gathered by individuals. Attitude towards science in newer terms has also been associated with attitudes such as perception of science teacher, value of science, attitude of parents and peers and also anxiety towards science (Osborne, Simon & Collins, 2003).

In this study, an attempt has been made to include the dimension of anxiety towards science, which is as defined as fear of concepts of science, scientists and activities related to science (Mallow, 1981). Various researches (Wynstra, 1991; Mallow, 2006) have identified anxiety as inability to handle equipment, communicate in class, performing homework/ classwork, anxiousness in problem-solving and doing calculations for physical sciences, interpreting graphs and tables. These characters can be lead from causes which are related to individual, environment and cognitive such as characteristics of teachers, teaching methods, attitude and confidence, readiness in the subject (Ma & Xu 2004). The AAAS (American Association for Advancement of Science) report on science calls for an intervention on part of science teachers to disregard anxiety as groundless and focus on ways to help overcome it. Hence, it becomes pertinent to first identify the prevalence of anxiety among students and also the various sources which have led to advent and manifestation of this occurrence.

Although a large number of studies have tried to construct a scale for attitude towards science but lack of construct validity is known to have a profound effect since the tools established are devoid of any thorough testing using factor analysis (Osborne, 2009). It has been found in a systematic review conducted by Potvin and Hasni, 2014 that between 2000 and 2012 out of 228 articles published and measuring attitude towards science only 3 were found to be psychometrically complete following validation and reliability principles. Another review for the years 1935 to 2005 (Blalock, 2008) reflects dearth of articles which have been standardized using correct validity and reliability measures, hence presenting with a limitation of inability to resolve correct dimensions and representation of items in the tests constructed.

In order to establish construct validity of instruments two forms of factor analysis – exploratory factor analysis and confirmatory factor analysis are most widely used. Exploratory factor analysis provides an opportunity to summarize a large number of information presented in form of variables, into condensed dimensions with minimum loss of information. For validation of results generated using EFA, a confirmatory factor analysis procedure is recommended. A confirmatory factor analysis relies not just on the statistical results but the theoretical understanding of the construct. Here the researcher specifies the factor structure even before the results can be computed, and thus represents how the measured variables represent the theoretical model in a coherent and organized manner.

Therefore the objective of the current study is to construct a valid and reliable instrument for assessing attitude towards science of secondary school students.

. Methodology

2.1 Participants

The participants in the study were 631 students selected randomly from 14 government schools of Chandigarh, India. The data was taken from schools after taking necessary permissions from District Education Officer, Chandigarh and also Principals of respective schools. Government schools of Chandigarh offer uniformity in terms of socio-economic status, syllabus followed and mode of instruction hence were appropriate for the study. Of the total sample 47 % were females (n=296) and 53 % were males (n= 335). Students belonged to the age group of 14-15 years.

Exploratory factor analysis was carried out on a sample of 431 students and for confirmatory factor analysis, 200 students comprised the sample of the study.

2.2 Development of attitude towards science scale

Based on TOSRA scale dimensions, review of literature and interaction with students a total of 51 items were framed. Out of these compiled items, 42 were retained after modification and elimination as suggested by 8 experts during content validity of the preliminary draft. For the 42 items 24 were negatively worded and 18 were positively worded.The instrument used a four-point Likert scale (1= strongly disagree, 4 = strongly agree) where negative items were reverse scored. Midpoint or neutral option was not used in the current scale as it has been recommended that removal of midpoint acts as a better measure for assessing intensity of participants attitude Dumas (1999), also midpoints are used by respondents as dumping grounds (Stone, 2004) and tend to appear as non committal, but since decisiveness of participants for the current construct was desirable therefore a four-point scale was used for this instrument. For determining the construct validity of the scale exploratory and confirmatory factor analysis was carried out.

Exploratory factor analysis

The revised scale was administered to a sample of 431 students for conducting exploratory factor analysis. For EFA a sample size of 10: 1 is recommended by Hair and Black, 2014.Whereas Bryant and Yarnold 1995 propose that sample size should be five times the number of variables. Comrey and Lee (1992) have classified 300 as a good, 100 as poor and 1000 as excellent sample size. Therefore, the above sample size was adequate.Principal axis factoring method was used for factor extraction (Hair &Black, 2014). Promax method of rotation was used since the factors are correlated to each other on theoretical backgrounds, hence oblique rotation techniques are used for which Promax rotation is designed to handle large datasets (Fields, 2003).

3. Data analysis

Prior to conducting factor analysis, assumptions of normality, multicollinearity were fulfilled and outliers were removed. Item total correlation was calculated and items with correlation below 0.3 (Hair & Black, 2014) were excluded from the study, therefore with 30 items left further factor analysis was carried out.

The very first step of factor analysis is to ascertain Kaiser–Meyer–Olkin measure of sampling adequacy (KMO) and Bartlett's test of sphericity for suitability of data.KMO value calculated was found to be 0.873 which is acceptable (Fields, 2003) and Bartlett's test of sphericity was also found to be significant (chi-square = 14729.103, $p < 0.001$) which means that correlation matrix is different from identity matrix hence the data can be utilized for factor analysis.

Communalities initially found were above 0.4, but for 2 items it was found to be less than 0.4, hence these items were removed (Costello & Osborne, 2005) and factor analysis was rerun. Finally, the communalities explained by extracted factors were more than 0.4 and the values lie between 0.47 to 0.97. Factors extracted were retained on the basis of three different methods. Firstly eigenvalue analysis was done for which Kaiser criterion was followed to retain factors above eigenvalues of 1(Kaiser, 1960).A total of five factors lied above eigenvalue of 1 and contributed to total variance of 78% (Table 1).

Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.944	31.943	31.943	8.708	31.101	31.101
2	5.012	17.899	49.843	4.784	17.085	48.186

3	3.365	12.017	61.859	3.181	11.362	59.547
4	2.440	8.716	70.575	2.113	7.548	67.095
5	2.080	7.428	78.003	1.871	6.682	73.777

Extraction Method: Principal Axis Factoring.

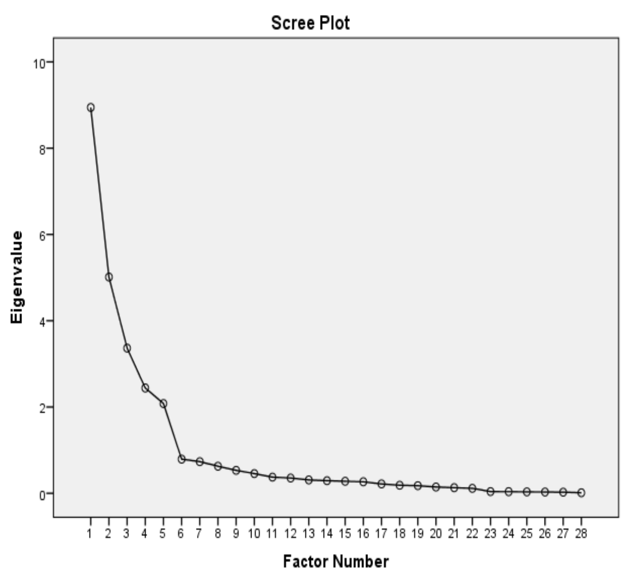
Table1 Eigenvalues and total variance explained by five factors.

Based on the Scree plot (Figure 1), factor 6 is the point at which the slope of graph changes dramatically, thus 5 factors can be retained (Catell, 1966). Another method used was a parallel analysis which can be done to prevent over-extraction of factors. In parallel analysis randomly generated eigenvalues using parallel analysis program are compared with calculated eigenvalues and the cutoff point at which random eigenvalues exceed calculated eigenvalues are considered as point for retention of factors (Horn, 1965). Thus with help of parallel analysis extraction of five factors was confirmed.

Based on table 2 factor loadings were found to be more than 0.7 for all five factors.The first factor was found to comprise of 8 items and contributed towards 31.9% of total variance, based on the type of items it was identified as “Anxiety towards science”. The second factor was formed of 7 statements and contributed to 17.89% of total variance and was identified as “Enjoyment of science lessons”. Similarly, third, fourth and fifth factor contained 4, 5 and 4 statements and were labeled as “Social implications of science”, “Career interest in science” and “Adoption of scientific attitudes”.

Reliability of the scale was determined using Cronbach Alpha and was found to be 0.917. For individual dimensions Cronbach Alpha was found to be 0.95, 0.94, 0.95, 0.89 and 0.91 respectively.

Figure 1 Scree Plot



	Factor				
	1	2	3	4	5
Q6	.970				
Q13	.965				
Q5	.947				
Q2	.934				
Q24	.789				
Q19	.784				
Q4	.739				
Q25	.736				
Q17		.937			

Q8		.924			
Q7		.912			
Q9		.859			
Q16		.817			
Q12		.742			
Q22		.733			
Q28			.986		
Q1			.967		
Q11			.857		
Q10			.832		
Q14				.905	
Q3				.810	
Q18				.776	
Q23				.727	
Q21				.726	
Q27					.991
Q20					.970
Q15					.754
Q26					.735

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.[a]
Table 2 Factor loadings of 28 items.

Confirmatory factor analysis

Confirmatory factor analysis was run on a sample of 200 students to validate the factor structure for the scale. The standardized factor loadings were found to be above the minimum level of 0.5 and were significant. Model fit indices generated showed that model fitted reasonably well (CMIN = 3.00, RMR= 0.045, CFI= 0.895, TLI= 0.884, RMSEA=0.100). It is recommended that AGFI and GFI measures should not be reported since these are affected by sample size (Sharma, Mukherjee, Kumar & Dillon, 2005).RMSEA value is considered acceptable from a range of 0.05 to 0.1 (Awang, 2012).CFI and TLI indices are recommended to be greater than or equal to 0.90 (Byrne, 2010; Hooper, Coughlan, & Mullen, 2008).According to (Kline, 2005) any index should not be solely relied upon and a combination of model fit indices should be used to define structure of the model. Hence, the model fit indices support a five-factor structure for measurement of attitude towards science.

Conclusion

The attitude towards science scale can serve as an effective instrument to assess students predispositions towards science, based on the psychometric properties of the scale. It can help understand attitude in terms of both positive and negative emotions towards science. Harnessing positive emotions and establishing the causes for negative emotions like anxiety can help stimulate the interest of students towards science and also instigate science career choices. The present scale can be used by teachers and researchers for age group of 14-16 years students and can find its application with survey and experimental based studies with high reliability and validity. Further testing and replication with larger samples and different populations are suggested.

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