Journal of Contemporary Teacher Education
Vol.III, 2019, 13-29

Development and Validation of Biology Attitude Scale for Secondary School Students in Islamabad, Pakistan

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Abstract

The aim of present study was to develop and validate an instrument to measure attitude of Students towards learning biology at 9th grade. It is imperative to ensure students' positive attitude towards biology at 9th grade as research has suggested that both attitude and achievement are inter-dependent. In order to develop the scale, a draft of 40 items on seven different constructs was developed after discussion with experts. The draft scale, was pilot tested on 200 grade 9 biology students (girls=97, boys=103). To determine construct validity, exploratory factor analysis with varimax rotated method was performed. Final scale reduced to 26 items with seven factors explaining 52.2% of the total variance. Overall, Cronbach's alpha reliability coefficient of the biology attitude scale was found 0.81. In view of above results, it is concluded that the developed scale is reliable and valid measurement tool for assessing students' attitude towards biology at secondary level.

Key words: Attitude, Exploratory factor analysis, Reliability coefficient, Construct validity.

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Introduction

Attention of people to study science has been increasing due to expanding advancement in science and technology and this is predominantly relevant in Pakistani scenario which is at the moment struggling for a reputable status among internationally growing communities and where the number of engineers and scientists are very low comparatively other developed countries. In order to confirm the invasion of new scientists, it is essential to understand that how science is to be taught in schools and how these practices affect learner's inclination toward playing active role in learning science.

It is important to understand students' attitude toward a particular discipline for supporting and guiding their achievement and interest in that discipline. There are numerous research studies highlighting students' attitude toward science (Dhindsa & Chung, 2003). But primarily, researches were associated significantly with attitude on science in general (Dawson, 2000) and less attention was given to subjects like Physics, Chemistry and Biology (Salta & Tzougraki, 2004). This cans somewhat disguise students' attitudes because science itself is not considered as homogeneous subject (Spall, Barrett, Stainistreet, Dickson & Boyes, 2003). In Pakistan, biology as a science subject is taught separately to the students of 9th grade. It is considered as a part of general science up to grade 8th in education system of Pakistan. The present study differs from the other studies concerning students' attitudes (Shah & Mahmood 2011) in the sense that it investigates students' attitudes toward biology rather than science only.

Rationale for the Development of Biology attitude Scale (BAS)

Researches on the development of scale to measure student's attitude towards science have been done by many in the field of science education. The most generally used instruments include, TOSRA (Test of Science Related Attitude) was developed and validated by Fraser (1981) and S.O.T (Scientific Orientation Test) was developed by Meyer (1995). Both above mentioned instruments related to student's attitude towards science. Keeping in view the limitations, researcher developed attitude scale for knowing students' attitude towards biology as a separate discipline at secondary level.

Objectives

The main objective of the current study was:

1. To develop biology attitude scale for secondary school students in Islamabad.
2. To establish the validity of the biology attitude scale using exploratory factor analysis.
3. To determine the reliability of the biology attitude scale.

Literature Review

In literature there are numerous definitions on the term attitude. Therefore, it is difficult to give one single definition on attitude which is accepted universally. However, almost all definitions manifest that attitude depict the idea like desirable or undesirable feelings, ideas or actions towards certain attitudinal objects (Petty, 1995). According to Eagly and Chaiken (1993) the attitude is considered as a psychological construct which includes three different components like cognitive, affective and behavioral respectively. The cognitive component of the attitude associated with the traits of the object, affective component concerning feelings about the attitudes' object and behavioral component involves the action of individuals toward particular object (Eagly & Chaiken, 1993). According to Koballa and Crawley (1985) the attitude can be observed as "a learned, positive or negative feeling about science that serve as a summary of wide variety of beliefs about science" (Koballa and Crawley, 1985). How attitude impact the learning of biology can be best understood by realizing following example. The announcement like that "I like biology" or "I don't like biology" indicate positive or negative feelings of individuals towards learning biology. Students with such varying opinion are subjected to the same set of instruction definitely produced different results. Affective dimensions sandwiching the cognitive and the behavioral dimensions in learning. In order to perform an effective teaching, it is essential for the subject teacher to understand this bridge on his/ her students.

In general student's attitude toward science decline with increase in grade level (Ramsden, 1998; Osborne, Simon, & Collins, 2003) boys show more positive attitude toward science than girls (Simpson & Oliver, 1985; Schibeci & Riley, 1986; O'Brien & Porter, 1994; Francis & Greer, 1999) and more negative attitudes are linked with physical sciences than biological science (e.g. Spall et al., 2003; Spall, Stanisstreet, Dickson, & Boyes, 2004).

Keeves (1992) and Jones, Howe and Rua (2000) reported that, girls show more positive attitudes toward biology than boys unlike

chemistry and physics. Dawson (2000) while comparing changes in interests and attitudes of Australian Students' over 20 years, reported that, girls shows more performance in human biology and general biology, but boys were intensely interested in earth sciences. Unlike gender differences, research on attitudes of UK students of age level 11-16, reported that attitudes toward biology show different age-related patterns than attitudes toward physics (Spall et al., 2004). According to Spall et al., (2004), Student's attitude toward physics becoming more negative with increase in age, relative to more positive attitudes towards biology.

Attitude has been extensively studied in the existing literature; it is still an issue to be studied because it is one of the predictors for effective learning. Biological concepts and sub concepts are of abstract nature which is difficult to understand. So, it is important to investigate students' attitudes toward biology.

The purpose of present study was to develop a valid and reliable attitude scale for 9th grade biology students to understand their liking or disliking about the subject of biology. The content of the biology scale developed is important as it is different to the already developed instruments in sense that it concerns with biology and also most suited to the researcher to utilize it for his doctoral study.

Methodology

It is keeping in view the importance to measure student's attitude towards science in general and biology in particular in school (Osborne et. al., 2003) the presently available attitude scales in the existing literature there is hardly any scale assessing student's attitude towards biology at secondary level in Pakistani scenario. In the recent past, attempt was made to translate and validate a scale to evaluate attitude towards science of students in Pakistan (Shah & Mahmood 2011). The present study was conducted to develop and validate biology attitude scale for 9th grade students. Researcher used 5- points Likert-Type scale; ranging from "strongly disagree" to "strongly agree" with "neutral" as the central point. Students' responses on five-point scale would be evaluated separately for positive and negative statements. In case of positive statements i.e. Strongly Disagree=1, Disagree=2, Neutral=3, Agree=4, Strongly Agree=5 and reversed in case of negative statements i.e. Strongly Disagree=5, Disagree=4, Neutral=3, Agree=2, Strongly Agree=1. This section provides details about the selection of subjects, different stages of scale development, validity and reliability of the final scale.

Sample

The sample was comprised of two hundred (200) students (97 girls and 103 boys) in model schools and Colleges in Islamabad under Federal Directorate of Education (FDE). The size of an appropriate sample does matter in conducting factor analysis and there are different opinions about it. The detail of sample size is given below:

Table 1
Sample Size and Characteristics

Sr. No.	Size of Sample	Remarks
1	50	Very Weak
2	100	Weak
3	200	Medium
4	300	Good
5	500	Very Good
6	1000	Perfect

Comrey & Lee, 1992

Keeping in view the above-mentioned opinions, researcher decide to go with medium level sample (N=200) for factor analysis.

Instrumentation

A 25-items biology attitude scale was developed to find out students' attitudes toward biology at secondary level. Five-point Likert-scale with seven dimensions (Interest in biology, career in biology, importance of biology, biology teacher, difficulties in biology, equipment used in biology and methodology of biology) was used. Development of biology attitude scale involves following steps (see figure 1 on next page).

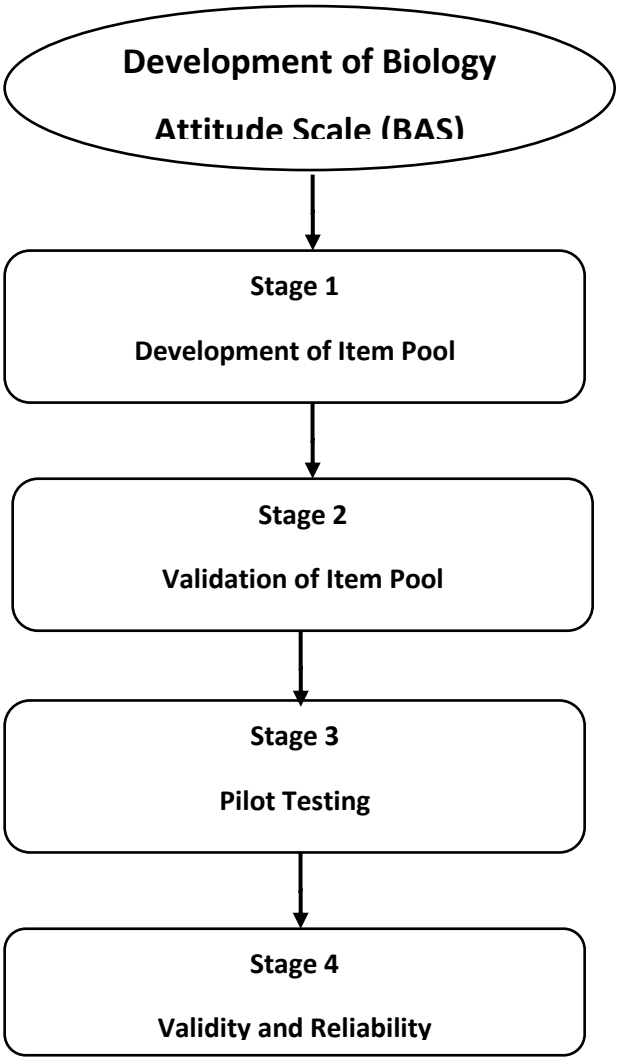

Figure: 1 Development process of biology attitude scale.

Step 1. Development of Initial Draft of Item Pool

Researcher extensively studies the different constructs concerning students' attitude toward biology, before the actual development of item pool. Then items were developed against each major construct while keeping in mind the teaching and learning

practices in local scenario. Initially, draft of the biology attitude scale was consisting of 40 items.

Step 2. Validation of Item Pool

Draft items of the biology attitude scale were examined by a panel of five judges who evaluate three areas: content validity, clearness and readability of the draft items. After receiving useful suggestions from experts, researcher carefully incorporates the changes based on the evaluation. On the basis of this external review, few items were rejected and numerous were revised. Finally, researcher left with an item pool of 35 items.

Step 3. Pilot Testing

Final draft of the biology attitude scale, which was designed according to experts' opinions, was applied to the sample of 200 students (girls= 97, boys=103) belonging to the different institutions under the umbrella of federal directorate of education, Islamabad. Sample of participants was comprised of 9^{th} grade biology students. For further statistical treatment, researcher entered student's responses into an excel file.

Step 4. Calculating Validity and Reliability

The data obtained from the sample of 200 students (girls=97, boys=103) were analyzed by using SPSS version 23.0. Construct validity of biology attitude scale can be measured by using factor analysis method (exploratory factor analysis). EFA was used to determine the latent structure of the biology attitude scale and the verification of such embedded structure (Secer, 2015). Reliability of the instrument was determined by applying technique of Cronbach alpha reliability coefficient.

Initially, researcher develop an item pool of 40 items was while keeping in mind the seven different constructs regarding students' attitude toward biology i.e. "Students' Interest in Biology", "Students' Career in Biology", "Importance of Biology", "Biology Teacher", "Difficulties in Biology", "Equipment use in Biology" and "Methodology of Biology". Then a panel of five experts evaluated the initial draft of 40 items for adjusting the content validity, clearness and readability. After incorporating suggestions obtained as a result of expert opinion, the list of items reduced to 35 (19 positive and 16 negative statements). It is suggested that Likert-type scale is easier and economical to develop comparatively others (Tavsancil, 2002). The basic characteristic of Likert-type scale is to make sure that all the items would measure the one and the same thing i.e. uni-dimensionality of the issue under consideration. The scoring criteria followed for 5-point Likert-type scale ranging from 1= S.D (Strongly Disagree) to 5= S.A

(Strongly Agree) through 3= N (Neutral) at the middle position for positive statements. It is reversed in term of negative statements. The final draft of 35 items was applied to 200 students (girls=97, boys=103) from different institutions under umbrella of Federal Directorate of Education (FDE) in Islamabad.

Table 2
Descriptive Analysis of Biology Attitude Scale (BAS)

Items	Mean	S.D.	Scale Mean if Item is Deleted	Corrected Item-Total Correlation	Cronbach's alpha if Item Deleted	N
Item 1	4.330	.7025	123.970	.426	.801	200
Item 2	3.140	1.2523	125.160	.230	.805	200
Item 3	3.965	1.2892	124.335	.232	.805	200
Item 4	4.120	1.1542	124.180	.475	.796	200
Item 5	4.080	1.1664	124.220	.255	.804	200
Item 6	3.650	1.1152	124.650	.270	.803	200
Item 7	3.895	1.2335	124.405	.442	.797	200
Item 8	2.595	1.3822	125.705	.052	.812	200
Item 10	4.230	1.1850	124.070	.316	.802	200
Item 11	4.215	1.1643	124.085	.222	.805	200
Item 12	2.995	1.4648	125.305	.316	.802	200
Item 13	3.790	1.1674	124.510	.364	.800	200
Item 14	4.065	1.1608	124.235	.460	.797	200
Item 16	4.070	1.2217	124.230	.286	.803	200
Item 21	3.955	1.1832	124.345	.493	.796	200
Item 22	3.925	1.2398	124.375	.505	.795	200
Item 23	4.095	1.0253	124.205	.303	.802	200
Item 24	3.830	1.1303	124.470	.453	.797	200
Item 25	3.475	1.4421	124.825	.276	.803	200
Item 26	4.210	1.1368	124.090	.499	.796	200
Item 29	3.895	1.2971	124.405	.410	.798	200
Item 30	3.740	1.1615	124.560	.259	.804	200
Item 31	3.750	1.2350	124.550	.371	.800	200
Item 33	3.005	1.2501	125.295	.260	.804	200

Item 34	3.390	1.1895	124.910	.190	.806	200
Item 35	4.185	1.1992	124.115	.390	.799	200
Item 9	3.595	1.2645	124.705	.137	.808	200
Item 15	3.055	1.5440	125.245	.039	.814	200
Item 17	3.360	1.3187	124.940	.302	.802	200
Item 18	2.535	1.4764	125.765	.147	.809	200
Item 19	3.670	1.1258	124.630	.206	.805	200
Item 20	3.795	1.2290	124.505	.494	.795	200
Item 27	3.040	1.24	125.26	.258	.804	200
Item 28	2.950	1.16	125.35	.010	.813	200
Item 32	3.705	1.15	124.59	.236	.804	200

Table 2 here, indicates the item-total correlation values for each individual item as well as and mean value of each scale item. It is suggested that item-total correlation should be positive but smaller than 0.25 (Ozdamer, 1997; Punch, 2005)). Item-total correlation values for 35 items remained between 0.50 to -0.10. Seven items out of 35 items were found with negative correlation values or values smaller than 0.25 and thus rejected. In order to confirm internal consistency of the scale, it is necessary to remove such items before the start of factor analysis. The scale with final 28 items generated a mean of 3.79 and standard deviation of 1.19.

Exploratory Factor Analysis

An exploratory factor analysis (EFA) was performed on the remaining items of the scale i.e. 28 items to observe the implicit structure underlying the scale. In order to observe the factor structure of the scale, varimax rotation method and principal component factor analysis were used. It is suggested to test the appropriateness of the data for conducting factor analysis by using Kaiser-Mayer-Olkin (KMO) and Barlett Sphericity Test (Ugulu, 2011). KMO (Kaiser-Mayer-Olkin) test is concerned with the measure of sampling adequacy and Barlett Sphericity test examined the sample sufficiency. In case of principal component factor analysis, the acceptable value of KMO test is 0.681. Table 3 here, shows values of KMO and Barlett's tests necessary for conducting factor analysis.

Table 3
The results of Kaiser-Meyer-Olkin and Barlett's tests

Kaiser-Mayer-Olkin (KMO) For Sample Adequacy		0.778
Bartlett's Test of Sphericity	Chi-Square	1383.660
	(Approx.)	378
	df	.000
	Sig.	

The scree plot graph of the attitude scale in which the eigen values are compared to the numbers of the factors. In this study, the investigator followed the criterion of eigenvalues ≥ 1 to determine the number of factors. Figure 2 clearly shows that the decline in the high curve was detected after the seventh factor. According to Field (2005), one could say that the attitude scale in biology has a seventh different factor.

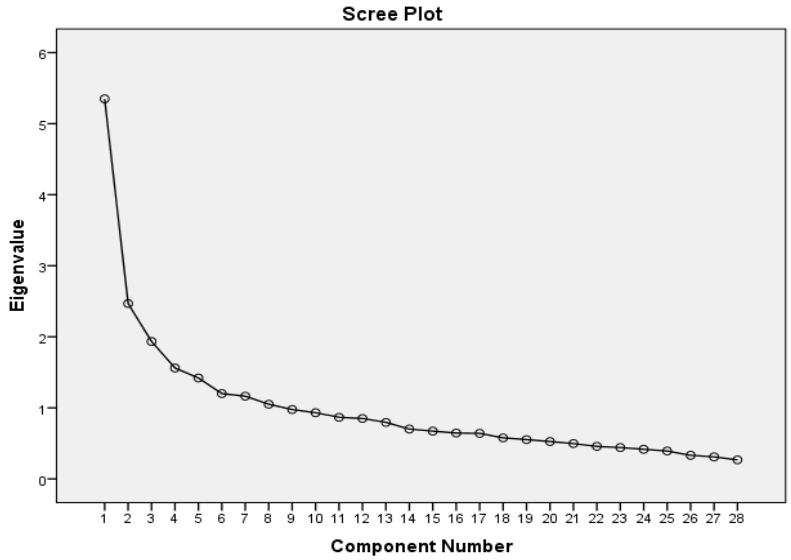

Figure: 2 The Scree Plot Graph of Biology Attitude Scale

Table 4

Factor Analysis of Biology Attitude Scale

No.	Statements	F_1	F_2	F_3	F_4	F_5	F_6	F_7
04	My Biology teacher is favorite one.	.549						
14	I prefer the teaching style of my Biology teacher	.758						
21	I have an easy access to my biology teacher when I have any problem in Biology.	.678						
22	I am not satisfied with teaching style of my biology teacher.	.727						
24	My biology teacher is strict in his dealing.	.649						
03	I would like to make a career in Biological sciences.		.754					
11	Biological knowledge is essential for my future career.		.573					
25	I would like to be a Biologist.		.757					
26	I am inspired by my Biology teacher.		.441					
29	There is no place for Biology in my future plans.		.709					
01	Biology is my favorite subject.			.682				
06	I deal Biology with feelings of hesitation.			.822				
16	I prefer to have more lessons on Biology.			.576				
02	The concepts and theories of Biology are too difficult to understand comparatively other science subjects.				.748			
33	I often face difficulties in understanding concepts in Biology.				.613			
34	Biology is the easiest subject for me.				.569			
12	We do not make use of Biology equipment.					.644		

31	I realize the importance of equipment when I prepare Biology lesson.					.683		
35	I dislike performing biology experiment.					.416		
05	Biological knowledge supports us in understanding other courses and phenomenon.						.688	
10	Biology is less important as compared to other science subjects.						.399	
23	The awareness in Biology is necessary for improving our lives.						.631	
07	Biology class is somewhat boring to me.							.472
08	I easily understand biological concepts during class time.							.776
13	It is easy to raise question during biology class.							.533
30	I am satisfied with the method of teaching Biology in my school.							.430
	Variance Explained (%)	13.2	8.65	6.36	6.33	6.05	5.83	5.74
	Total Variance Explained (%)							52.2

Factors: $\mathbf{F_1}$=Biology Teacher, $\mathbf{F_2}$=Career in Biology, $\mathbf{F_3}$=Interest in Biology, $\mathbf{F_4}$=Difficulties in Biology,
$\mathbf{F_5}$=Equipment use in Biology, $\mathbf{F_6}$=Importance of Biology and $\mathbf{F_7}$=Methodology of Biology

In order to establish the construct validity of the attitude scale a principal component factor analysis with varimax rotation was used. As can be seen from Table 4 the consequences of factor analysis including factor loading and the variance explained (in Table 5).

Table 5
The Results of Factor Loading and Variance of each Factor

Factors	% of total Variance	Factor Loading	
		From	To
F_1	13.282	0.549	0.749
F_2	8.657	0.441	0.757
F_3	6.360	0.576	0.822
F_4	6.333	0.569	0.748
F_5	6.059	0.416	0.683
F_6	5.833	0.399	0.688
F_7	5.740	0.430	0.776

After applying principal component factor analysis with varimax rotation method factor F_1 (Biology Teacher) comprised of five items with factor loading ranging from 0.549 to 0.749. The scale items in factor F_1 are 04, 14, 21, 22 and 24. Factor F_2 (Career in Biology) comprised of five items with factor loadings ranging from 0.441 to 0.757. The scale items in factor F_2 are 03, 11, 25, 26 and 29. Factor F_3 (Interest in Biology) comprised of three items with factor loadings ranging from 0.576 to 0.822. The scale items in factor F_3 are 01, 06 and 16. Factor F_4 (Difficulties in Biology) comprised of three items with factor loadings ranging from 0.569 to 0.748. The scale items in factor F_4 are 02, 33 and 34. Factor F_5 (Equipment use in Biology) comprised of three items with factor loadings ranging from 0.441 to 0.757. The scale items in factor F_5 are 12, 31 and 35. Factor F_6 (Importance of Biology) comprised of three items with factor loadings ranging from 0.416 to 0.683. The scale items in factor F_6 are 05, 10 and 23. Factor F_7 (Methodology of Biology) comprised of four items with factor loadings ranging from 0.430 to 0.776. The scale items in factor F_7 are 07, 08 and 13.

The last factor containing just one item which was decided to include in factor third as it doesn't affect its Cronbach's alpha reliability co-efficient. One item in first factor being irrelevant was discarded. The items with minimum factor 0.41 were accepted as valid.

Reliability of the Attitude Scale

The Cronbach's alpha coefficient of the biology attitude scale was 0.81 that considered as highly reliable for the research instrument (Hogan, 2003). According to Spooren, Mortelmans & Denekens (2007), the Cronbach-alpha value more than 0.70 is satisfactory. Hence, it is concluded that the items in the attitude scale are reliable with each other and measure the same construct. Therefore, it is confirmed that the biology attitude scale is a consistent as well as valid research instrument.

Conclusions and Recommendations

In the present study, exploratory factor analysis of the BAS was made to assess 9th grade student attitudes toward biology. The procedure for developing attitude scale was comprised of four steps: (1) Development of initial draft of item pool; (2) validation of item pool; (3) pilot testing; and (4) validity and reliability. In step-1, researcher involved in extensive study of the different constructs concerning student attitudes towards biology. As a result, researcher developed an item pool of 40 items. In step-2, taking opinion of five judges in term of content validity, readability and language of item involved in initial draft. After incorporating changes, the draft reduces to 35 items. In step-3, researcher administered final draft of 35 items to 200 students (boys=103, girls=97) for pilot testing. In step-4, construct validity of the attitude scale was determined by applying procedure of factor analysis with varimax rotation. As a result, researcher left with 25 statements belonging to seven different constructs: Students' attitude towards interest in biology, students' attitude towards career in biology, students' attitude towards importance of biology, students' attitude towards biology teacher, students' attitude towards difficulties in biology, students' attitude towards using equipment in biology and students' attitude towards methodology of biology. The reliability co-efficient of the attitude scale was found as $\propto = 0.81$, which is acceptable.

It is recommended that the present attitude scale should be used by researchers in different research studies, like experimental and descriptive, to determine student's attitude towards biology. It is important to mention that the current biology attitude scale may come across with testing its factor structures as well as its usage in varied samples. Also, it is recommended that the subject teachers must check attitude of their student at the beginning and ending of an academic session.

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