# The Discriminant Validity and Reliability for Urdu Version of Test of Science–Related Attitudes (TOSRA)

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## Abstract

*The aim of this study was to explore the psychometric properties of an Urdu translation of the Test of Science-Related Attitudes (TOSRA-Urdu). 1885 secondary school students from the Punjab province of Pakistan completed the TOSRA-Urdu approximately three months before taking the Secondary School Certificate examinations. The values of alpha reliabilities in the present study, after analysis of data, were 0.67, 0.72, 0.88, and 0.87 for Social Implications of Science, Attitude to Scientific Inquiry, Classroom Enjoyment and Leisure Interest in Science, and Career Interest in Science respectively. Similarly the values of discriminant validity for these scales in this study ranged from 0.27 to 0.34. The TOSRA-Urdu has showed sufficient validity and reliability to be used in subsequent research in Urdu speaking people.*

**Key Words*:*** Attitude, attitude towards science, discriminant validity, reliability, Test of Science-Related Atitudes (TOSRA)

## *Introduction*

Koballa (1988) has described that the term attitude was first used in the beginning of 18th century. In the field of psychology, it was first used by Thomas and Znaniecki (1918). According to Choppin and Frankel (1976), "it is almost universally acknowledged that educational objectives in the affective domain --- those dealing with attitudes, interests and values --- are of great importance" (p. 57).

The term 'attitude' is very common and popular in daily life. Everyone has given it its own meanings, concepts and definitions. According to Thurstone (1928), the definition of attitude is "the sum total of man's inclination and feelings, prejudice and bias, preconceived notions, ideas, fears, threats and convictions about any specified topic" (p. 531). Another definition of attitude described by Thurstone (1931) is "the effect for or against a psychological object" (p. 261). Then Thurstone (1946) modified his previous definitions and described new one as "the intensity of positive or negative effect for or against a psychological object" (p. 39).

**Definitions and Concepts of Attitude towards Sciences**

Gardner (1975) has defined attitude towards science as "a learned disposition to evaluate in certain ways, objects, people, actions, situations or dispositions involved in learning science" (p. 2). Similarly, Osborne, Simon, and Collins (2003) gave the definition of attitude as "the feelings, beliefs and values held about an object that may be the enterprise of science, school science, the impact of science on society or scientists themselves" (p. 1053).

"There is a considerable consensus of opinion that the promotion of favorable attitude is an important aim of science education. There is confusion about what meaning should be placed on the 'attitude' to science" (Fraser, 1981, p.1). Bennet (2003) has made it clear that different interpretations have been made on the term 'attitude' and 'science'.

Schibeci (1984) has described that science-related attitudes are generally divided into two categories: scientific attitudes and attitude towards science. Gardner (1975) has associated scientific attitude to scientific method or thinking styles of students only. On the other hand, Bennet (2003) has described that attitude towards science refers to the views of students developed for science as the results of experiences in different environments in the field of science education.

**The Measurement of Attitudes**

Laforgia (1988) has described that students' attitudes towards science have been measured by using different techniques like interviews, projective techniques, open-ended questionnaires, closed-items questionnaires and preference rankings etc.

In the present study, Test of Science-Related Attitudes (TOSRA: Fraser, 1981) was used to measure attitude of $10^{th}$ grade students towards science. This instrument was used due to the reasons that:

1) Test of Science-Related Attitudes provides a separate score for a number of distinct categories. This is the advantage of TOSRA over other attitude measuring instruments (Eccles, 2007).
2) According to Fraser (1981), it is specially designed for the secondary school science students to measure their attitudes towards science.
3) Adolphe (2002) describes that teachers and researchers have found TOSRA to be a useful and easy-to-use instrument for the measurement of students' attitude towards science.

**Introduction and Background of TOSRA**

According to Fraser (1981), TOSRA is designed to measure the secondary school students' attitude towards science. The theoretical basis for the Test of Science-Related Attitudes (TOSRA) came from the categories of Klopfer (1971) for the attitudinal domain in the field of science education. According to Fraser (1978), initially, there were five scales of first developed TOSRA. Then, two new scales i.e. Normality of Scientists and Career Interest in Science were added. The seven scales of TOSRA by Fraser (1981) are: Social Implications of Science, Normality of Scientists, Attitude to scientific Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science and Career Interest in Science (p. 1).

According to Eccles (2007), "each scale contains ten items and the students have to respond on a 5-point Likert type scale. These responses are: (1) Strongly Agree, (2) Agree, (3) Not Sure, (4) Disagree, and (5) Strongly Disagree. About half of the items in TOSRA are reverse-scored" (p. 57).

**Review of Research Studies using TOSRA**

Fraser and Fisher (1982) administered TOSRA on 116 students of $8^{th}$ and $9^{th}$ grade classes while conducting a research on anxiety and science-related attitudes. In another study on gender differences in attitude towards science, Smist, Archambault, and Owen (1997) administered TOSRA among 572 high school students. All the seven scales of TOSRA were used in this study.

Test of Science–Related Attitudes (TOSRA) was modified by Wong and Fraser (1996) into Questionnaire on Chemistry-Related Attitudes (QOCRA). This modified version of TOSRA was used to examine students' attitude towards chemistry.

This questionnaire was administered on 1,592 students of chemistry classes selected from 28 public schools. Similarly, this modified instrument QOCRA was also used by Quek, Wong, and Fraser (2005) in another study for the determination of students' chemistry-related attitudes. This instrument was also an adapted version of TOSRA.

Smist (1996) conducted a research study on self-efficacy, attributions and attitudes toward science. He administered TOSRA on 411 high school students for the measurement of attitude towards science. In another study, Joyce and Farenga (1996) used TOSRA on 111 high ability students while conducting a research study on science-related attitudes, science-related experiences and future interest in science.

Rana (2002) used TOSRA to measure higher secondary school students' attitudes toward science. He translated the original version of TOSRA into Urdu language and administered on 2,144 students of Punjab province in Pakistan. All of the seven scales of TOSRA were used in this study. The reliability coefficient for TOSRA in this study was 0.9104.

Test of Science–Related Attitudes (TOSRA) was also administered by Adolphe (2002) for the measurement of attitudes among junior secondary science students in Australia and Indonesia. On the other hand, Adamski, Peiro, and Fraser (2005) used modified Spanish Version of TOSRA in their study to measure Spanish students' attitude towards science. The data was collected from 223 Spanish students of grades 4 through 6. Two scales of TOSRA: The Adoption of Scientific Attitudes and Enjoyment of Science Lessons were translated into Spanish language.

Wolf and Fraser (2008) conducted a research by administering the modified version of TOSRA for the assessment of students' attitude towards science. The data was collected from 1,434 students from 71 classes. Factor loadings for all items were above 0.30. In another research study, Eccles (2007) also used TOSRA on middle school students in South Florida for measuring students' attitudes toward science.

In the latest research study, Test of Science–Related Attitudes (TOSRA) was administered by Fraser, Aldridge, and Adolphe (2010) on a sample of 1,161 students of Australia and Indonesia. Three scales of TOSRA i.e. Normality of Scientists, Attitude to Scientific Inquiry, and Career Interest in Science were used in this study. These scales of TOSRA were translated into Indonesian language for Indonesian students.

### *Aim of this study*

The aim of this study was to translate the TOSRA into Urdu and then check the properties of this measure to establish its reliability and validity for use in future research. Although these theoretical predictions are replications of existing research, the research described here offers an extension to the extent literature by establishing the reliability and validity of the TOSRA in a new culture; an important step in preliminary research.

## *Method*

### *Participants*

Data was collected from $N$ = 1885 secondary school students drawn from sixty four schools located in four districts from the Punjab province of Pakistan. The sample was stratified so that data was collected from equal numbers of schools in urban ($n$ = 1197) and rural ($n$ = 688) locations, single sex girls' ($n$ = 887) and boys' schools ($n$ = 998) in each of the four districts in Punjab province. Participants were in the $10^{th}$ grade of school (the final year of compulsory education in Pakistan), aged 15-16 years in which students take public Secondary School Certificate (SSC) examinations in math's, physics, chemistry and biology. Institutional and individual consent was provided.

### *Measure*

TOSRA was translated into Urdu language and then standardized on higher secondary school students of Punjab province by Rana (2002). There were seven scales and 70 items in the original version of TOSRA by Fraser (1981). But Rana (2002) used 60 items in his adapted version.

In the present study, all the 42 items of the five scales "Social Implications of Science, Attitude to Scientific Inquiry, Enjoyment of Science Lessons, Leisure Interest in Science and Career Interest in Science" from the translated and standardized version of TOSRA by Rana were used.

The researcher took the written permission to use TOSRA from its developer Prof. Dr. Barry Fraser, Director of Science and Mathematics Education Centre, Curtin University of Technology, Australia.

The Table 1 below presents the number of statements in each subscale of Test of Science-Related Attitudes (TOSRA).

**Table 1: Number of Statements in each Subscale of TOSRA**

| TOSRA Subscales | Number of Statements |
|---|---|
| Social Implications of Science | 8 |
| Attitude to Scientific Inquiry | 7 |
| Enjoyment of Science Lessons | 10 |
| Leisure Interest in Science | 7 |
| Career Interest in Science | 10 |

**Pilot Testing of TOSRA**

The TOSRA-Urdu was pilot tested on 200 tenth grade science students of public secondary schools. The students were studying Physics, Chemistry, Biology, and Mathematics as science subjects. For pilot testing, the Alpha Reliability Coefficient of TOSRA used in this study was $\alpha = 0.842$. Table 2 below shows the mean, standard deviation, and reliability coefficient value of TOSRA for the pilot testing.

**Table 2: Mean, Standard Deviation, and Reliability Coefficient of TOSRA**

| Mean | Standard Deviation | Cronbach Alpha Reliability Coefficient |
|---|---|---|
| 158.1350 | 17.0246 | 0.842 |

The reliability coefficients were also calculated for each subscale of TOSRA which are given in Table 3 as below:

**Table 3: Reliability Coefficients for Subscales of TOSRA**

| TOSRA Subscales | Number of Statements | Alpha Reliability Coefficients |
|---|---|---|
| Social Implications of Science | 8 | 0.657 |
| Attitude to Scientific Inquiry | 7 | 0.634 |
| Enjoyment of Science Lessons | 10 | 0.720 |
| Leisure Interest in Science | 7 | 0.699 |
| Career Interest in Science | 10 | 0.709 |

After pilot testing, item analysis was performed. Table 4 below presents the item statistics and the values of Discrimination Index for pilot testing.

**Table 3.11: Item Statistics and Item-Total Correlations for TOSRA**

| Item Number | Mean (Difficulty Index) | Item-Total Correlation (Discrimination Index) |
|---|---|---|
| TOS 1 | 4.007 | 0.177 |
| TOS 2 | 4.250 | 0.237 |
| TOS 3 | 4.471 | 0.415 |
| **TOS 4** | **3.064** | **0.097** |
| **TOS 5** | **4.350** | **0.012** |
| TOS 6 | 4.257 | 0.492 |
| TOS 7 | 4.129 | 0.476 |
| TOS8 | 3.679 | 0.226 |
| TOS9 | 4.164 | 0.296 |
| **TOS 10** | **1.443** | **-0.058** |
| **TOS 11** | **1.971** | **-0.048** |
| TOS 12 | 3.993 | 0.321 |
| TOS13 | 3.943 | 0.328 |
| TOS14 | 4.071 | 0.433 |
| TOS15 | 4.121 | 0.385 |
| TOS16 | 4.179 | 0.287 |
| TOS17 | 3.543 | 0.342 |
| TOS18 | 4.586 | 0.348 |
| **TOS 19** | **1.950** | **-0.048** |
| **TOS 20** | **3.700** | **0.076** |
| TOS 21 | 3.700 | 0.330 |
| TOS 22 | 3.521 | 0.350 |
| TOS 23 | 4.686 | 0.321 |
| TOS 24 | 4.286 | 0.349 |
| TOS 25 | 3.400 | 0.339 |
| TOS 26 | 4.557 | 0.230 |
| TOS 27 | 4.064 | 0.351 |
| TOS 28 | 4.250 | 0.447 |
| **TOS 29** | **1.764** | **-0.079** |
| TOS 30 | 3.093 | 0.387 |
| TOS 31 | 4.300 | 0.497 |
| TOS 32 | 3.550 | 0.299 |
| TOS 33 | 3.907 | 0.345 |
| **TOS 34** | **3.693** | **0.050** |
| TOS35 | 4.407 | 0.408 |
| TOS 36 | 4.229 | 0.416 |
| **TOS 37** | **1.814** | **-0.096** |
| **TOS 38** | **1.843** | **-0.061** |
| **TOS 39** | **3.186** | **0.025** |
| TOS 40 | 4.250 | 0.415 |
| TOS 41 | 4.200 | 0.481 |
| TOS 42 | 3.026 | 0.372 |

On the basis of values given in Table 4, item numbers 4, 5, 10, 11, 19, 20, 29, 34, 37, 38, and 39 were rejected and deleted from the adapted version of TOSRA. Remaining 31 items were retained in the final questionnaire.

**Development of Final Instrument of TOSRA**

The final questionnaire of TOSRA consisted of 31 items. This 31 item TOSRA was used for the data collection of the present study (English version for this 31-itemed final TOSRA is attached as Appendix). The Alpha Reliability value for the final TOSRA was $\alpha = 0.899$.

Table 5 below shows the number of items, item numbers retained in the final instrument, and the Alpha Reliability values of each subscales of TOSRA.

**Table 5: Items and the Reliability Coefficients of Final TOSRA Subscales**

| TOSRA Subscales | Number of Statements | Serial Number of Statements in Final Test of 31 Items | Alpha Reliability Coefficients |
|---|---|---|---|
| Social Implications of Science | 6 | 1,7,9,14,20,26 | 0.897 |
| Attitude to Scientific Inquiry | 5 | 2,10,16,21,23 | 0.742 |
| Enjoyment of Science Lessons | 8 | 3,4,11,17,22,24, 27,29 | 0.892 |
| Interest Leisure in Science | 5 | 5,12,18,28,30 | 0.791 |
| Career Interest in Science | 7 | 6,8,13,15,19,25,31 | 0.861 |

The revised version of TOSRA after pilot testing contained 31 items with following proportions of five subscales:

- Social Implications of Science with 6 items
- Attitude to Scientific Inquiry with 5 items
- Enjoyment of Science Lessons with 8 items
- Leisure Interest in Science with 5 items
- Career Interest in Science with 7 items

The revised version TOSRA was field tested and the data was collected from a sample of 1,885 students.

**Factor Analysis**

Factor analysis was used to identify the small number of factors that were used to represent relationships among sets of interrelated variables and to understand correlations between or among the components or factors. KMO and Bartlett's Test of Sphericity were used to examine the appropriateness of factor analysis and to examine the correlation of variables.

***KMO and Bartlett's Test of Sphericity***

According to Tabachnick and Fidell (2001), the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is an index used to examine the appropriateness of factor analysis. High values of KMO (between 0.5 and 1.0) indicate that factor analysis is appropriate. Values below 0.5 imply that factor analysis may not be appropriate. Similarly, Bartlett's test of sphericity was used to examine that variables are uncorrelated in the population.

Table 6 below shows the values of Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity.

**Table 6: KMO and Bartlett's Test**

| Kaiser-Meyer-Olkin Measure of Sampling Adequacy | | 0.617 |
|---|---|---|
| Bartlett's Test of Sphericity | Approx. Chi-Square | 788.537 |
| | Df | 15 |
| | Sig. | .000 |

It is concluded from Table 6 that KMO measure is 0.617. From the same table, we can see that the Bartlett's test of sphericity is significant ($p < 0.001$). This shows that the degree of common variance among the variables is quite high; therefore factor analysis can be conducted.

***Factor Structure for Revised Version of TOSRA***

Ledesma and Mora (2007) have described that factor analysis is a technique widely used in social sciences.

According to Nunnally and Bernstein (1994), factor structure is very important tool to measure the psychological constructs. Gorsuch (1983) has described that "a prime use of factor analysis has been the development of both the operational constructs for an area and the operational representatives for theoretical constructs" (p. 350). According to Zaman (2011), a Kaiser Eigenvalue criterion decides to choose the factors. According to Kaiser (1960) Eigenvalue rule, only factors that have Eigenvalues greater than one are retained for interpretations.

Keeping in view the above discussion, the internal structure of revised version of TOSRA was examined by using the principal axis factor analysis with Varimax rotation. The factor loadings obtained are described in Table 7. Factor loadings of 0.30 or higher are expressed in this table. The criterion for an item to be retained is described by Nelson (2005). According to this criterion, only that item is retained in an instrument whose factor loading is at least 0.30 on its own scale and less than 0.30 on all other scales.

The application of this criterion led to the removal of some items of the revised version of TOSRA scale. Item number 9 was deleted from subscale *Social Implications of Science.* Similarly, item numbers 3, 22, and 27 from *Enjoyment of Science Lessons,* item number 28 from *Leisure Interest in Science,* and item number 15 from *Career Interest in Science,* were deleted. All of these items (3, 9, 15, 22, 27, and 28) had loadings of less than 0.30 on their own scales and were omitted from subsequent analyses.

After conducting factor loading procedure, two subscales of TOSRA: *Enjoyment of Science Lessons* and *Leisure Interest in Science* were merged into a single subscale named *Classroom Enjoyment and Leisure Interest in Science.* This new subscale consisted of 9 items. Table 7 shows that revised version of TOSRA consists of 25 items with following 4 scales:

Table 7 below presents the factor loadings, percentage of variance, and eigenvalues for four scales of TOSRA.

**Table 7: Factor Analysis Results for the Revised Version of TOSRA**

| Item | Factor Loadings | | | |
|---|---|---|---|---|
| | Social Implications of Science | Attitude to Scientific Inquiry | Classroom Enjoyment and Leisure Interest in Science | Career Interest in Science |
| 1 | 0.38 | | | |
| 7 | 0.53 | | | |
| 14 | 0.54 | | | |
| 20 | 0.36 | | | |
| 26 | 0.32 | | | |
| 2 | | 0.36 | | |
| 10 | | 0.48 | | |
| 16 | | 0.49 | | |
| 21 | | 0.46 | | |
| 23 | | 0.50 | | |
| 4 | | | 0.49 | |
| 11 | | | 0.55 | |
| 17 | | | 0.46 | |
| 24 | | | 0.43 | |
| 29 | | | 0.44 | |
| 5 | | | 0.45 | |
| 12 | | | 0.45 | |
| 18 | | | 0.50 | |
| 30 | | | 0.39 | |
| 6 | | | | 0.50 |
| 8 | | | | 0.38 |
| 13 | | | | 0.45 |
| 19 | | | | 0.41 |
| 25 | | | | 0.56 |
| 31 | | | | 0.71 |
| % Variance | 16.51 | 8.48 | 6.01 | 5.6 |
| Eigenvalue | 4.29 | 2.21 | 1.56 | 1.45 |

- Social Implications of Science with 5 items
- Attitude to Scientific Inquiry with 5 items
- A combined Classroom Enjoyment and Leisure Interest in Science with 9 items
- Career Interest in Science with 6 items

The bottom of the table shows that the percentage of variance was 16.51 % for Social Implications of Science, 8.48 % for Attitude to Scientific Inquiry, 6.01 % for Classroom Enjoyment and Leisure Interest in Science, and 5.6 % for Career Interest in Science. Similarly, the eigenvalues for four scales of TOSRA ranged from 1.45 to 4.29. Overall, the various analyses expressed in Table 7 support a strong structure for 25 items with four scales of revised version of TOSRA.

**Internal Consistency Reliability for Revised Version of TOSRA**

According to Eccles (2007), "the internal consistency reliability of any scale is a measure of the extent to which items within the same scale assess the same construct" (p. 69). Table 8 below shows the internal consistency reliability of each scale of TOSRA.

**Table 8: Internal Consistency Reliability (Cronbach Alpha Coefficient) for Two Units of Analysis for Revised Version of TOSRA**

| Scales | No. of Items | Units of Analysis | Alpha Reliability |
|---|---|---|---|
| Social Implications of Science | 5 | Individual | 0.56 |
| | | Class Mean | 0.67 |
| Attitude to Scientific Inquiry | 5 | Individual | 0.60 |
| | | Class Mean | 0.72 |
| Classroom Enjoyment and | 9 | Individual | 0.73 |
| Leisure Interest in Science | | Class Mean | 0.88 |
| Career Interest in Science | 6 | Individual | 0.71 |
| | | Class Mean | 0.87 |

Sample consisted of 1885 students in 64 classes.

Table 8 shows that alpha reliability of different scales of revised version of TOSRA ranged from 0.56 to 0.73 with the individual student as the unit of analysis and from 0.67 to 0.88 with the class as the unit of analysis.

The results of Table 8 express that the revised version of TOSRA have satisfactory internal consistency reliability when used with 10$^{th}$ grade science students in the Punjab province.

**Discriminant Validity for the Revised Versions of TOSRA**

Discriminant validity for the finally revised version of TOSRA was measured by using the mean correlations of the scale with other scales.

Table 9 below shows the discriminant validity (mean correlation with other scales) with two units of analysis for four scales of revised version of TOSRA.

**Table 9: Discriminant Validity (Mean Correlation with other Scales) for Two Units of Analysis for Revised Version of TOSRA**

| Scales | No. of Items | Units of Analysis | Mean Correlation with Other Scales |
|---|---|---|---|
| Social Implications of Science | 5 | Individual | 0.19 |
| | | Class Mean | 0.27 |
| Attitude to Scientific Inquiry | 5 | Individual | 0.22 |
| | | Class Mean | 0.29 |
| Classroom Enjoyment and | 9 | Individual | 0.30 |
| Leisure Interest in Science | | Class Mean | 0.34 |
| Career Interest in Science | 6 | Individual | 0.23 |
| | | Class Mean | 0.33 |

Sample consisted of 1885 students in 64 classes.

Table 9 indicates that discriminant validity of an individual student as unit of analysis ranged from 0.19 to 0.32 for the scales of TOSRA. Similarly, the discriminant validity for class as unit of analysis ranged from 0.27 to 0.40 for scales of TOSRA. The results indicated that raw scores on scales of TOSRA are highly independent at individual level, but these scales overlap at class mean as unit of analysis.

**Ability of the Revised Version of TOSRA to Differentiate between Classrooms**

For evidence of validity, one-way Analysis of Variance (ANOVA) was used to check whether all scales of finally revised version of TOSRA were able for significant differentiation between perceptions of students in different classes.

Table 10 below shows the internal consistency reliability ANOVA results for two units of analysis for four scales of revised version of TOSRA.

**Table 10: Internal Consistency Reliability (Cronbach Alpha Coefficient) and Ability to Differentiate between Classrooms (ANOVA Results) for Two Units of Analysis for Revised Version of TOSRA**

| Scales | No. of Items | Units of Analysis | Alpha Reliability | ANOVA Eta² |
|---|---|---|---|---|
| Social Implications of Science | 5 | Individual | 0.56 | 0.10*** |
| | | Class Mean | 0.67 | |
| Attitude to Scientific Inquiry | 5 | Individual | 0.60 | 0.10*** |
| | | Class Mean | 0.72 | |
| Classroom Enjoyment and Leisure Interest in Science | 9 | Individual | 0.73 | 0.10*** |
| | | Class Mean | 0.88 | |
| Career Interest in Science | 6 | Individual | 0.71 | 0.09*** |
| | | Class Mean | 0.87 | |

***$p < 0.001$ N = 1885 students in 64 classes.

Table 10 expresses that each scale of TOSRA differentiate significantly ($p < 0.001$) between classrooms for all the students of 64 schools. The value of Eta² ranges from 0.09 to 0.13 for the 10th grade science students. The data for alpha reliability and Eta² presented in Table 10 is in conjunction with the results of factor analyses shown in Table 4.6. It indicates that all four scales of TOSRA are valid and reliable for the measurement of students' attitude towards science. So, researchers can use these revised versions of TOSRA.

## *Discussion*

The findings from internal consistency reliability (Cronbach alpha coefficient) and discriminant validity in the present study have confirmed that Test of Science-Related Attitudes (TOSRA) is found to be valid and reliable. The value of alpha reliability coefficient calculated for Urdu version of TOSRA in the pilot testing of the present study was 0.842. This value given by Fraser (1981) was 0.840. Rana (2002) also used Urdu version of TOSRA among Pakistani students and the value of alpha reliability for Urdu version of TOSRA by Rana was 0.914. In the present study, five scales (later on four) of TOSRA were used while Fraser and Rana used all seven scales of TOSRA. The values of alpha reliabilities in the present study were 0.67, 0.72, 0.88, and 0.87 for Social Implications of Science, Attitude to Scientific Inquiry, Classroom Enjoyment and Leisure Interest in Science and Career Interest in Science, respectively. The values of these scales given by Fraser were 0.82 for Social Implications of Science, 0.79 for Attitude to Scientific Inquiry, 0.80 (average) for Enjoyment of Science Lessons and Leisure Interest in Science, and 0.84 for Career Interest in Science. It is very clear that these values of four scales of TOSRA in the present study replicated to the values given by Fraser.

Similarly, the values of discriminant validity for these scales in this study ranged from 0.27 to 0.34. Likewise, the values given by Fraser ranged from 0.13 to 0.40. Some other studies have also supported the arguments that the values of alpha reliability and discriminant validity resembled to the values given in the present study (Fraser et al., 2010; Eccles, 2007; Wolf & Fraser, 2005; Adamski et al., 2005; Adolphe, 2002; Smist et al., 1997; and Fraser & Fisher, 1982).

All the values of alpha reliability and discriminant validity in this study replicated the results of previous research studies and made it clear that TOSRA was valid and reliable when used in Pakistani context among 10th grade science students of Punjab province. At the end, it is suggested that the same research or any other research similar to this one can be conducted on all levels i.e., from primary level up to university level. Similarly, This research may also be conducted on students taking subjects of arts. So, its results can be generalized for whole of the population including students of science as well as arts.

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**Appendix**

**Test of Science-Related Attitudes (TOSRA) for Study**

SA=Strongly Agree, A=Agree, NS=Not Sure, DA=Disagree, SDA=Strongly Disagree

| Sr. No. | Statements | SA | A | NS | DA | SDA |
|---|---|---|---|---|---|---|
| 1 | Money spent on science is well worth spending. | | | | | |
| **2** | I would prefer to find out why something happens by doing an experiment than by being told. | | | | | |
| **3** | Science lessons are fun. | | | | | |
| **4** | I dislike science lessons. | | | | | |
| **5** | I get bored when watching science programs on TV at home. | | | | | |
| **6** | When I leave school, I would like to work with people who make discoveries in science. | | | | | |
| **7** | Public money spent on science in the last few years has been used wisely. | | | | | |
| **8** | I would dislike a job in a science laboratory after I leave school. | | | | | |
| **9** | Scientific discoveries are doing more harm than good. | | | | | |
| **10** | I would rather agree with other people than do an experiment to find out for myself. | | | | | |
| **12** | I dislike reading books about science during my holidays | | | | | |
| **13** | Working in a science laboratory would be an interesting way to earn a living. | | | | | |
| **14** | The government should spend more money on scientific research. | | | | | |
| **15** | A career in science would be dull and boring. | | | | | |
| **16** | I would rather find out about things by asking an expert than by doing an experiment. | | | | | |
| **17** | Science lessons are a waste of time | | | | | |
| **18** | Talking to friends about science after school would be boring. | | | | | |
| **19** | I would like to teach science when I leave school. | | | | | |
| **20** | Science helps to make life better . | | | | | |
| **21** | I would rather solve a problem by doing an experiment than be told the answer | | | | | |
| **22** | I really enjoy going to science lessons. | | | | | |
| **23** | It is better to ask the teacher the answer than to find it out by doing experiments. | | | | | |
| **24** | The material covered in science lessons is uninteresting. | | | | | |
| **25** | A job as a scientist would be interesting. | | | | | |
| **26** | Science can help to make the world a better place in the future. | | | | | |
| **27** | I look forward to science lessons. | | | | | |
| **28** | I would enjoy visiting a science museum at the weekend. | | | | | |
| **29** | I would enjoy school more if there were no science lessons. | | | | | |
| **30** | I dislike reading newspaper articles about science. | | | | | |
| **31** | I would like to be a scientist when I leave school | | | | | |