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RESEARCH PAPER

Development and Validation of Students' Attitude towards Science Scale (SATSS) for 7th-Grade Students

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ABSTRACT

Science education is attracting increasing attention, and several researchers focus on the issue of the attitude toward science, but there is still no consistent conclusion. Due to its strong relationship to the growth of a society's economy, science education is a crucial subject for students to learn. As attitude is a complicated concept, the primary studies' use of various operationalization methods for measuring it may have produced inconsistent results. In this research, the main objective was to develop and validate a scale to measure the students' attitudes toward science of 7th-grade students. Students' Attitude towards Science Scale (SATSS) has four sub-factors: SIN, SIQ, KLS, and COLLA. In this research, the researcher follows the five steps (development and validation of test, findings, conclusion, and recommendations). The initial draft consisted of four sub-factors and 31 statements. The validity and reliability of the scale were ensured by using specific criteria. CFA was also run by using SPSS and Amos 24. After running the CFA, seven (7) statements were deleted from the scale. After that, the final Students' Attitude towards Science Scale (SATSS) comprised 24 statements. The results consequently provided evidence to use the Students' Attitude towards Science Scale (SATSS) to measure students' attitudes toward science of 7th-grade students.

Keywords: 7th-grade, Attitude toward Science, Science Subject, SATSS

Background

Today, science offers the foundation for success in many aspects of modern life. To accomplish this, students must maintain precision attention on their teachers throughout their academic careers. Science is an important subject for secondary school students to study. After secondary school, these students must select majors that will develop their professional careers. These pupils must complete many assignments at this level. Through these exercises, students pick up many concepts about science and scientific inquiry.

According to Tai et al. (2006), science education is a crucial subject for students due to its strong relationship to the growth of a society's economy. Building a good attitude toward science and increasing young people's enthusiasm for pursuing scientific jobs are two goals of science education (Azizoglu & Etin, 2009). Across many regions of the world, the recent reduction in students' positive attitudes about science and the declining number of students choosing to major in science have sparked intense societal concern and debate (Potvin and Hasni, 2014; Kennedy et al., 2014; Cheng and Wan, 2016). Lack of enthusiasm for science and the poor interest among young people in pursuing science occupations are severe dangers to the economic development of a country (Osborne et al., 2003; Kennedy et al., 2016).

Science education helps children in grasping scientific concepts, claims Bennett (2003). In the above discussion, consideration has been given to students' attitudes toward science. How do these considerations relate to their success in the study of science? A huge volume of research on what affects pupils' science achievement. Some variables are learning

environment, ability, parental influence, self-efficacy, parental socioeconomic status, attitude toward science, test anxiety, peers, gender, and teachers (Gertyz, 1998; Joyce & Farenga, 2000; Rodriguez, 2004).

Literature Review

Allport (1935) defines it as an intellectual and neural condition of willingness structured through experience, applying a directive or vigorous impact on the person's reaction to all things and the associated circumstances. Thurstone (1946) states that attitude is our psychological association with some object, whether positive or negative. Attitudes are the result of organized experiences and hidden learning as well. This attitude is reflected in the personality of the person (Zimbardo & Lieppe, 1991).

According to Osborne et al. (2003), students' attitudes regarding science, whether favorable or unfavorable, depending on how they view science as a subject of school, a part of society, and a human endeavor. A person's attitude can affect various perceptions, views, and ideals about science and their enthusiasm to pursue potential professions. Attitude is a somewhat more dispositional construct that changes slowly.

According to Wigfield and Eccles (2000), the expectancy-value theory, a student's attitude toward science can be explained by two primary components (Eccles & Wigfield, 2002): the student's expectations of success and the value that the student places on success. These include the notion that the student can learn science in school, the anticipation of academic success, and the value and necessity of learning science. The expectancy-value theory provides a psychological foundation for studying enduring attitudes toward science and momentary, situational motives. The Relevance of Science Education project questionnaires on student attitudes toward school science ask about ability views, expectations of success, career values, and social values (Schreiner & Sjberg, 2004).

While they progress through elementary school, student's attitudes toward science tend to become more unfavorable for various reasons.

- As they get older, students get interested in various extracurricular activities.
- Poor performance in schoolwork.
- A greater focus on specific scientific truths.
- A stronger focus on test outcomes
- Students don't have many opportunities to enjoy science (Nair & Fisher, 2001).

Researchers have employed various techniques over the past three decades to measure students' attitudes toward science. One such frequently used method is paper and pencil. This technique used rating and situational set questions based on a format similar to that created by Osgood or Likert (Reid, 2006). Most often, attitudes have been assessed using items from surveys that use the Likert scale (Simons, 2000). These scales are believed to possess advantages and disadvantages that come with them naturally. To collect relevant data, researchers must demonstrate the validity and reliability of their tools, yet a persistent problem has been observed with these tools' weak psychometric qualities (Gardner, 1996; Reid, 2006; Ramsden, 1998; Munby, 1997; Osborne & Reid, 2003). Results were obtained; however, they were difficult to interpret and lacked the accuracy needed to understand attitude improvement in science education due to the weak psychometric qualities of the attitude scales (Gardner 1996; Reid, 2006). Hence, it was determined that instruments to measure attitudes toward science must be developed that are statistically valid and trustworthy (Gardner, 1996; Munby, 1997).

Many researchers used different attitude instruments to measure the attitude from different perspectives regarding different subjects. According to Afzal, Saleem, and Islam (2015), researchers refer to many emotional states of the human mind using terminologies like interest, attitude, and motivation. Afzal, Saleem, and Islam (2015) studies students' attitudes regarding mathematics. Students' attitudes toward mathematics are a composite of various factors, such as how they approach mathematical research, how much they like math lessons, and how they adopt that attitude. Their attitude toward it assesses one's preference for employing mathematics inquiry. Ramzan, Saleem, Islam, and Afzal (2014) developed a valid and reliable scale named PTTAS. This scale was used to measure the attitude of teachers regarding their profession. Andleeb and Islam (2021) developed and validated TAS-TER to measure the attitude regarding the teaching of English reading.

Methodology

Development of the Instrument

Using a SATSS that the researcher developed, the researcher examined the students' attitudes toward science in this study. This scale was developed following a thorough analysis of previous studies. First, the researcher used the general science curriculum documents to take the attitude subscale (2006). Scientific Interest, Scientific Inquiry, Keenness to Learn Science, and Collaboration were the four sub-scales that comprised this research. Second, the researcher constructed each of these four measures' English-language statements. Third, the first version of the attitude scale had four (4) variables and 31 sentences. According to Fraenkel, Wallen, and Hyun, (2012) Likert scale, the scale's values were changed to reflect the strong agreement, agreement, neutrality, disagreement, and disagreement. The degree of agreement or disagreement with the claims about the person, item, or circumstance is described using the Likert scale.

The statements of the scale were developed according to the intellectual level of the students. Therefore, the statements' language was very easy and simple to understand. The table below shows detailed info on each sub-scale, including the number of statements.

Table 1
Detail of Sr. No. of Statements in the Final Scale

Sub-Scales	Description	No. of Items	Sr. No. of Statements in Final Scale
Scientific Interest	An emotion that is connected to or attra focuses on something or someone.	10	1,5,9,13,17,21,24,27,29,31
Scientific Inquiry	By employing scientific inquiry as a method problem-solving and questioning, students c better understand observable events.	9	2,6,10,14,18,22,25,28,30
Keenness to Learn Scienc	The quality of having a passion for science	5	3,7,11,15,19
Collaboration	To cooperate or work together, especially in intellectual endeavor.	7	4,8,12,16,20,23,26
Total Items		31	31

Expert Validation

The experts reviewed the preliminary version of the SATSS scale. These experts professional professors belong from different universities. Experts are requested to provide their judgment and feedback on each scale statement. According to the suggested comments and feedback of the experts, the document was modified and improved.

Content Validity

The Content Validity Ratio (CVR) for each statement and Content Validity Index (CVI) of the overall scale was calculated to enhance the quality and validity of the

questionnaire, known as the Students' Attitude towards Science Scale (SATSS). Because the Content Validity Ratio (CVR) value of all the items (31) was greater than 0.49, no item was removed or excluded from the questionnaire. All items' Content Validity Ratios (CVRs) fell between 0.857 and 1.00. CVI for three to five experts is 1.00, and for six to ten experts, it is 0.78. CVI's average value is 0.90. (Waltz, Strickland, & Lenz, 2010). A CVR value of more than 0.49 is regarded as acceptable. However, the overall Content Validity Index (CVI) of the questionnaire remained at 0.949 for fourteen (14) experts, which is the greatest value of CVI (Lawshe, 1969).

Table 2
CVR of items and CVI of SATSS

Item No.	Statement	CVR	Mean	Decision
SInt01	I like watching science movies.	0.857	2.928	Retained
Slnt05	I prefer to watch a scientific documentary while it is playing on TV.	0.857	2.928	Retained
Slnt09	I search for science projects on YouTube.	1.00	3.00	Retained
Slnt13	I like to learn new scientific concepts.	0.857	2.928	Retained
Slnt17	I talk to my friends about scientific discoveries and inventions.	1.00	3.00	Retained
Slnt21	I do scientific experiments at home.	0.857	2.928	Retained
Slnt24	I like spending time in science labs.	0.857	2.928	Retained
Slnt27	In my spare time, I like to read / listen to science fiction stories.	1.00	3.00	Retained
Slnt29	In my spare time I like to read / listen to science based articles.	1.00	3.00	Retained
Slnt31	I enjoy reading scientific knowledge.	1.00	3.00	Retained
SInq02	I look for answers to the questions asked in the science class.	1.00	2.928	Retained
SInq06	I find it interesting to know the reason for the scientific facts.	1.00	2.928	Retained
SInq10	I like to explore the wonders of natural phenomena.	1.00	3.00	Retained
SInq14	It is important for me to know about the topics covered in the science book.	0.857	2.928	Retained
SInq18	I do research on information provided on science topics in science classes.	1.00	3.00	Retained
SInq22	I respect the right opinion when discussing science, even if it is against my thinking.	1.00	3.00	Retained
SInq25	I correct my mistakes with new information.	0.857	2.928	Retained
SInq28	I do not immediately dismiss anything.	0.857	2.928	Retained

SInq30	I like to do it again to check the results of the experiments.	1.00	3.00	Retained
KLS03	I listen carefully the lectures in science class.	1.00	3.00	Retained
KLS07	I understand the key points in the science class.	0.857	2.928	Retained
KLS11	I adhere strictly to my schedule for studying science at home.	1.00	3.00	Retained
KLS15	I repeat the science lessons taught daily at home.	1.00	3.00	Retained
KLS19	I complete my science work before playing.	0.857	2.928	Retained
Colla04	I like to make a science model with the help of my friends.	1.00	3.00	Retained
Colla08	I learn more when I work in a group in a science class.	1.00	3.00	Retained
Colla12	I enjoy doing scientific experiments with friends.	0.857	3.00	Retained
Colla16	I like to make scientific models with the help of friends.	1.00	3.00	Retained
Colla16	I like to make scientific models with the help of friends.	1.00	3.00	Retained
Colla20	I like to take part in science photography competitions in science class.	0.857	2.928	Retained
Colla23	I enjoy group study in science class.	0.857	2.928	Retained
Colla26	I learn more during group study.	1.00	3.00	Retained

Pilot Testing

The required sample size for factor analysis is 10–15 participants for each item (Hof, 2012). As a result, 1006 students in the 7th grade who were enrolled in various government schools in Punjab, Pakistan, were asked to take the Students' Attitude towards Science Scale (SATSS) as a pilot project. The responders to the pilot testing did not include the sample. Ensure the concept and discriminant validity of the scale; confirmatory (CFA) factor analysis was employed. The analysis was done using statistical software, SPSS version 24, and Amos to verify the reliability of the SATSS.

Model fit of Confirmatory Factor Analysis (CFA)

The Comparative Fit Index (CFI), Chi-Square Goodness of Fit (CMIN/df), Adjusted Goodness of Fit Index (AGFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Regression Weights were the statistics used by the researcher to assess the model fit. Although less than 0.05 is preferred, CFI >.90 and close to 1, TLI (rho2) >.90, and RMSEA >.08 are acceptable (Xia & Yang, 2019). Consequently, Confirmatory Factor Analysis (CFA) was carried out using AMOS, and the estimated values were computed accordingly.

Table 3
Criterion Values for Confirmatory Factor Analysis

Indicators Consistency	Index Value Before Modification	Index Value After Modification	Function Value on the Quality of Conformity
CMIN/df	4.217	3.683	< than 3
CFI	0.869	0.923	> than 0.9
AGFI	0.864	0.907	> than 0.9
TLI (rho2)	0.858	0.913	> than 0.9
RMSEA	0.057	0.052	≤ .08 is accepted but < 0.05 is good

Xia & Yang (2019)

The table demonstrates that the CMIN/df ratio value was more than 3 (4.217) and did not satisfy the model fit requirement. The tested AGFI value was 0.869, which was less than the required value of 0.9. This number did not satisfy the model fit requirement. The covariance matrix between variables required to be reviewed as a result. TLI value was discovered to be 0.858, which was less than the required value of 09. This number did not satisfy the model fit requirement. The covariance matrix between variables required to be reviewed as a result.

The RMSEA value was also observed to be 0.54. The model is "reasonably fit" when the RMSEA is less than.08; nevertheless, a "near fit" is defined as greater than 0.05. (Xia & Yang, 2019). This number almost exactly satisfies the model fit requirement at 0.5. Additionally, the standardized regression weights for the Students' Attitude towards Science Scale (SATSS) against each item were calculated.

Table 4
Standardized Regression Weights of Items of SATSS before Modification

Sub-Scales	Items	Standardized Regression Weights
Scientific Interest	SINT01	.497
	SINT02	.507
	SINT03	.616
	SINT04	.566
	SINT05	.690
	SINT06	.641
	SINT07	.520
	SINT08	.667
	SINT09	.652
	SINT10	.576
Scientific Inquiry	SINQ01	.538
	SINQ02	.528
	SINQ03	.486
	SINQ04	.574
	SINQ05	.635
	SINQ06	.327
	SINQ07	.497
	SINQ08	.484
	SINQ09	.654
Keenness to Learn Science	KLS01	.587
	KLS02	.533
	KLS03	.654
	KLS04	.544
	KLS05	.444
Collaboration	COLLA01	.620
	COLLA02	.579

	COLLA03	.629
	COLLA04	.686
	COLLA05	.621
	COLLA06	.546
	COLLA07	.619

Standardized regression weights for each item are shown in Table 4. However, the AGFI and TLI readings were lower than the required value of 0.9. The covariance matrix between the variables needed to be reevaluated. It is possible to exclude the question from the questionnaire with the lowest Standardized Regression Weight. Due to their values being below.520, the entries SINT01 (.497), SINT02 (.507), SINQ03 (.486), SINQ06 (.327), SINQ07 (.497), SINQ08 (.484), and KLS05 (.444) were deleted or eliminated. The table above displays the model fit summary of the 7th-grade SATSS. The factor structure of the SATSS Scale is depicted in the figure below.

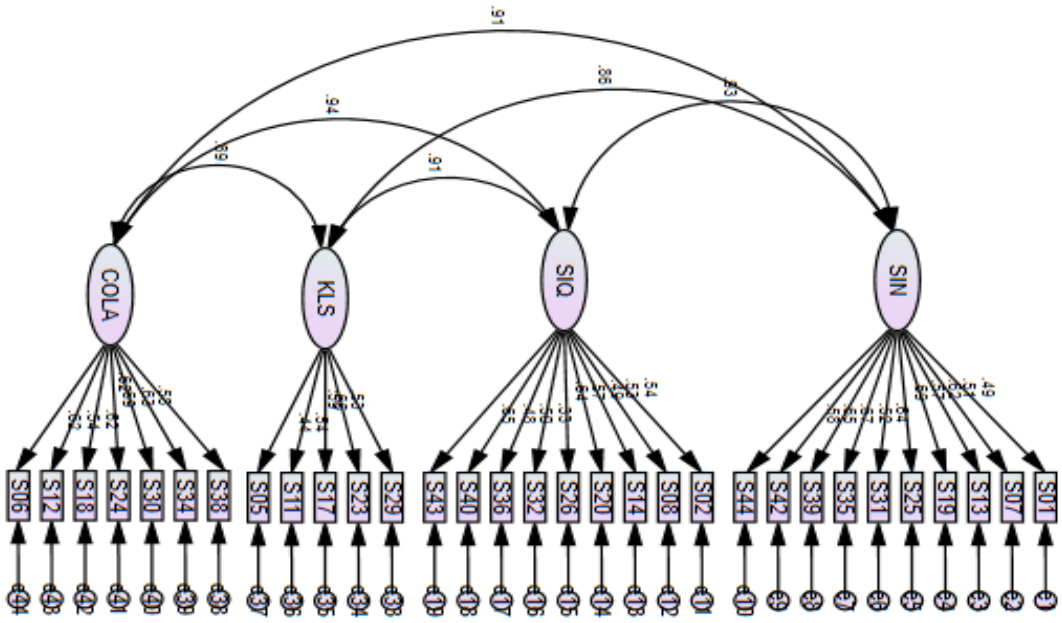

Figure 1: Factor Structure of SATSS before Modification

Following the item deletion, CFA was rerun using Amos Software. The table below gives a summary of the value.

Findings

After removing the statements from the SATSS, the values of the final SATSS were shown in given table below.

Table 5
Criterion values for Confirmatory Factor Analysis

Indicators Consistency	Index Value Before Modification	Index Value After Modification	Function Value on the Quality of Conformity
CMIN/df	4.217	3.683	Less than 3
CFI	0.869	0.923	Greater than 0.9
AGFI	0.864	0.907	Greater than 0.9
TLI (rho2)	0.858	0.913	Greater than 0.9
RMSEA	0.057	0.052	≤ .08 is accepted but < 0.05 is good

Xia & Yang (2019)

The values of the modified/adjusted model are presented in Table 5. The CMIN/DF ratio result, 3.683, met the model fit condition and was lower than the previous value. According to Marsh and Hocevar (1985), the CMIN/df ratio is fair and acceptable if it is less than 5. Analysis revealed that the AGFI value was 0.907, greater than the needed value of 09. The value of the modified model meets the Model Fit criteria. The criteria value, which was 9, was lower than the TLI score, which was 0.913. This number meets the Model Fit criterion at this time. Similar results were found for the RMSEA value, which was 0.52 and very close to 0.5. When the RMSEA value is less than 0.08, the model has a "good fit," but a "close fit" is defined as less than 0.05. 2019 (Xia & Yang). At 0.5, this number nearly meets the model fit criteria.

Table 6
Standardized Regression Weights of Items of SATSS After Modification

Sub-Scales	Items	Standardized Regression Weights
Scientific Interest	SINT03	.616
	SINT04	.566
	SINT05	.690
	SINT06	.641
	SINT07	.520
	SINT08	.667
	SINT09	.652
	SINT10	.576
Scientific Inquiry	SINQ01	.538
	SINQ02	.528
	SINQ04	.574
	SINQ05	.635
	SINQ09	.654
Keenness to Learn Science	KLS01	.587
	KLS02	.533
	KLS03	.654
	KLS04	.544
Collaboration	COLLA01	.620
	COLLA02	.579
	COLLA03	.629
	COLLA04	.686
	COLLA05	.621
	COLLA06	.546
	COLLA07	.619

The results were shown to have improved when the standardized regression weights were generated for each item in Table 6.

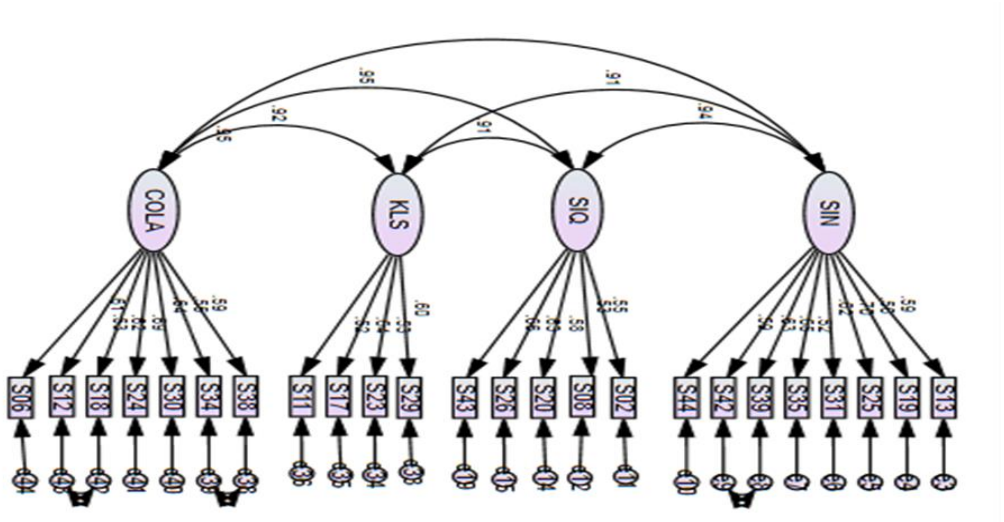

Figure 2: Factor Structure of SATSS after Modification

The SATSS statistics above show that the model has become fit with 24 retained items on four sub-scales.

Assessing SATSS, the Modified Model Fits with Sample Data

The SATSS has been modified, amended, and changed several times. It turned into a fit model. Additionally confirmed was the CFA pictorial illustration of SATSS, which is seen below. The SATSS components were loaded into four (4) sub-factors: SIN, SIQ, KLS, and COLLA, according to the graphic depiction. In addition to the five things loaded against SIQ, eight items were loaded against SIN. There were four (4) things loaded against KLS. Additionally, COLLA was loaded with seven (7) things. While the covariance matrix between the variables was examined, the maximum covariance was found for SINT06, SINT07, COLLA01, COLLA02, COLLA05, and COLLA06. In order to fit the model, covariance was calculated between these variables. Confirmatory factor analysis was performed using the AMOS software (CFA).

Table 7
Reliability of SATSS

Sub-Scales	Number of Items	Mean	SD	Reliability Coefficient
Scientific Interest	8	32.47	6.89	0.828
Scientific Inquiry	5	21.33	3.81	0.729
Keenness to Learn Scienc	4	17.18	2.99	0.632
Collaboration	7	29.00	5.91	0.809
SSAS Overall	24	99.99	17.29	0.923

The table displays the SATSS results, which demonstrate the validity and reliability of the final questionnaire model. The scale has been compressed to twenty-four (24) items with a reduction factor of 0.923, out of which eight (8) items were retained for scientific interest, five (5) items were retained for scientific inquiry, four (4) were retained for eagerness to learn science, and seven (7) were retained for collaboration. As a result, there is enough evidence to support the validity and reliability of the SATSS in assessing the attitudes of 7th-grade science students.

Conclusion

According to all the test statistics, the SATSS performed well and achieved its objective. SATSS measures the 7th- grade students' attitude toward science. The CVI value of each item was greater than 0.05; It indicates that each item was both statistically important and applicable in a practical context. The reliability value was 0.92, which is up to the standard, indicating that SATSS was reliable.

Recommendations

The following recommendations are made in light of the above conclusions and observations. Teachers may use the developed Students' Attitude towards Science Scale (SATSS) to measure their students' attitudes toward science and improve classroom practices to change the students' attitudes regarding science subject. Furthermore, the researcher may adhere to a validation procedure to evaluate the instrument's reliability. Moreover, other researchers may take this study as a starting point for the same issue or may incorporate other themes that are not restricted to those gained from participants' responses.

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