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Development and Validation of the Scientific Attitude Scale for School Students

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***Abstract**: At present, India is at the stage where it has the great chance to leverage its demographic dividend, digital infrastructure, and growing academic talent to emerge as **'vishwa guru', a global leader.** To fully realize the vision of becoming a global leader, it is important for the nation to increase investment in research and development, foster collaboration between academia and industry, and strengthen science education at the school and higher education levels. Within this context, it becomes imperative at the school level to assess and inculcate the scientific temper, interest, and attitude among the students.*

This study was carried out with the objective of developing a Scientific Attitude Scale (SAS) to assess the attitude of students towards science, focusing on secondary school students. This scale is grounded on four key constructs, designed on a 5-point Likert scale, which was administered on a diverse student sample, subjected to psychometric testing. The scale underwent a process including content validation, pilot testing, item analysis, and reliability estimation. Findings confirmed that the SAS is a psychometrically sound instrument with high internal consistency and construct validity. The study discusses the implications of using the tool for diagnostic and pedagogical planning in the context of competency-based education frameworks like the National Curriculum Framework (NCF) 2023.
Keywords: Scientific Attitude, School Students, Research Tool, Development, Validation, and Science Education.
***Keywords:** Eco-criticism, eco-spirituality, visual sacredness, affinity, tranquillity, equilibrium*

1. Introduction: Science in India

India possesses a long heritage of scientific exploration of thousands of years, with initial achievements in mathematics, astronomy, metallurgy, medicine, and agriculture. From the initial philosophical searches into nature to advanced space exploration, India's scientific heritage is both intellectually enriched and enduring (Raj, P., Farswan, Y.S., & Ahmed, N. 2023). India's scientific heritage can be traced to the Indus Valley Civilization (2500–1500 BCE), with proof of sophisticated town planning, drainage, metallurgy, and weights and measures showing early technological awareness. This suggests that the creation and use of scientific ideas in India might be traced back well to the Paleolithic era (Old Stone Age), which further developed over time. During the Vedic era (1500–500 BCE), astronomy, mathematics, and medicine started to form, based on texts like the Rigveda and Atharvaveda. In astronomy, Varahamihira's Pancha Siddhantika synthesized astronomical information from several sources. In medicine, the Charaka Samhita and Sushruta Samhita formed the base for Ayurveda, describing surgical procedures, anatomy, and pharmacology. In addition, during the medieval era, Indian science was in contact with Persian and Arab learning. Developments in astronomy and algebra progressed but at a slow pace, as under Muslim rule, science started to recede with decreased state sponsorship and a drift back to religious orthodoxy.

Subsequently, in the contemporary Indian era, European colonial forces, especially the British, were a milestone. Western science was brought about by the advent of missionary schools and

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colonial universities, which resulted in a new educational system. Organisations like the Indian Association for the Cultivation of Science (1876) and the University of Calcutta (1857) promoted scientific studies and research. The period saw the pioneering Indian scientists. Jagadish Chandra Bose contributed to plant physiology and radio waves. Prafulla Chandra Ray paved the way to modern chemistry, and Satyendra Nath Bose, in association with Einstein, formulated Bose-Einstein statistics. Nobel Laureate C.V. Raman, in 1930, discovered the Raman Effect, a breakthrough in optics. This highlights the fact that the development of Science in India was ongoing and continuous.

Following the Independence, which was celebrated in 1947, Prime Minister Jawaharlal Nehru advocated for a scientific mind set as an important support of national progress. Some major institutions such as the Indian Institutes of Technology (IITs), Indian Space Research Organisation (ISRO), the Department of Atomic Energy (DAE), Defence Research and Development Organisation (DRDO), Council of Scientific and Industrial Research (CSIR), Department of Space and Department of Environment were founded (https://www.psa.gov.in/article/75-years-indian-science-and-technology-mission-sustainability-and-self/4092). Science was being connected closely with national objectives, enhancing agriculture, technological self-sufficiency, and industry modernization. 1976, long remembered as a watershed moment in Science in India, when India adopted the idea of 'science temper' into its constitution. The Green Revolution, nuclear energy mission, and space explorations proved the power of scientific development to fuel national development. And, pursuing the heritage of the green revolution, India has increasingly made strides in the fields of agri-genomics and genome editing, with targeted efforts aimed at enhancing crop yields and creating robust varieties suited to the challenges of modern agriculture and environment.

India's scientific landscape is currently boosted by a large network of institutions such as CSIR, which consists of more than 35 laboratories and contributes to applied science and industrial R&D. The other is Department of Science and Technology and Department of Biotechnology, which also support and coordinate scientific research in India. Top institutions such as IISc, IITs, NITs, and IISERs develop the future scientists and engineers and perform innovative research.

Recently, India's space mission under the leadership of ISRO has made headlines worldwide for affordable and innovative missions. The Chandrayaan-3 mission resulted in India being the first to land on the Moon's south pole, and the Mars Orbiter Mission (Mangalyaan) was a low-cost historic success (Pandey, G., 2023, BBC News). Moreover, India has built a strong nuclear program for power generation and defense. The civil nuclear program is handled by the Bhabha Atomic Research Centre (BARC) and Nuclear Power Corporation of India Ltd. (NPCIL). Not just this, but India is also a global IT services and software development hub. The development of the industry has been facilitated by STEM (Science, Technology, Engineering, and Mathematics) education offered in schools and in higher education. To complement it even more, the Government of India (GoI) has launched some policies and programs. India's Education policy, the 'National Education Policy (NEP) 2020', also identifies the significance of developing not just intellectual competencies but also socio-emotional and attitudinal inclinations that equip students for the 21st century.

It promotes a holistic, integrated, and question-driven process of learning with a focus on conceptual understanding, scientific temper, and problem-solving rather than mere memorization (Pg 4, paras 4.23, 9.1.1, 11.8 NEP 2020). In consonance with NEP 2020, the National Curriculum Framework (NCF) 2023 extends this vision further by focusing more on competency-based and experiential learning. It encourages the development of a scientific mindset from early grades and integrates these objectives across disciplines, particularly within science and mathematics education. As it is universally recognized that the cultivation of

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scientific temper and attitude among youth and future generations is of vital significance for the development of individuals, society, and the country, let us see how scientific attitude and temper help shape a personality, nation, and achieve sustainability collectively (Fig. 1):

Figure 1: Areas developed by Scientific Attitude and Temper

Although the trend is positive, Indian science has a number of systemic challenges. Let us examine the current challenges facing India (https://sabrangindia.in/the-science-problem-why-india-lags-behind-in-research-development/). India's GERD is approximately 0.7% of GDP, much lower than nations such as China (2.4%) or the USA (3.5%). It is largely funded by the public sector, while private sector investment is limited. Another significant challenge is brain drain (https://news.abplive.com/science/india-science-challenges-how-to-overcome-brain-drain-indigenous-equipment-development-experts-say-1622754). Most bright scientists and engineers go abroad for employment since the infrastructure, research grants, and academic autonomy are superior there. Additionally, Science education in India is more concentrated on rote memorization and entrance exams than experimental learning and understanding concepts. Rural and disadvantaged regions suffer from trained teachers and laboratory infrastructure. India is at a critical juncture at which it can leverage its demographic dividend, digital infrastructure, and higher education talent to emerge as a scientific leader in the world (https://www.ipsos.com/en-in/india-harnessing-its-demographic-dividend).

Fields such as quantum computing, renewable energy, biotechnology, space exploration, and AI have vast opportunities. To accomplish this dream, India needs to boost research and development expenditures, facilitate cooperation between industry and academia, improve science education at the school level, particularly in disadvantaged regions, foster inclusivity and support for underrepresented groups in STEM, and facilitate multi-disciplinary research (Figure 2).

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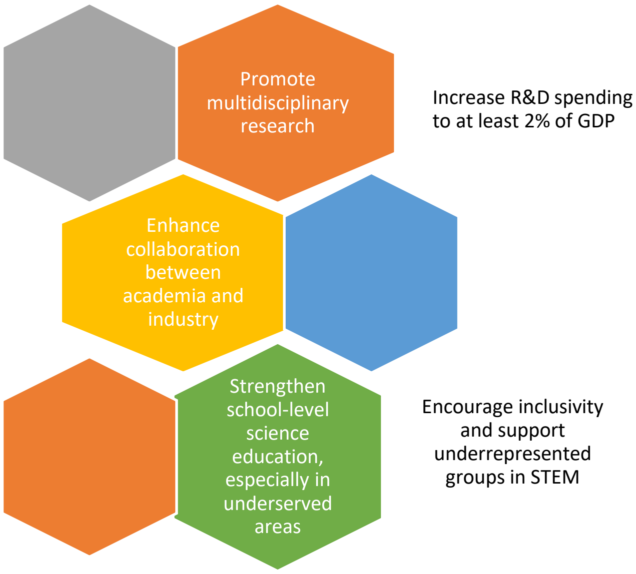

Figure 2: Areas to work to promote Science and Technology in the Country

2. Review of Related Literature

For laying a strong groundwork for the present study, a comprehensive literature review was conducted by the researcher. Some of the most appropriate reviews, pertinent to the topic of scientific attitude in School Education are given below:

Osborne, Simon, and Collins (2003) systematically reviewed existing research on students' attitudes towards science and their implications for science education. The results indicated that science attitudes are formed by several interrelated variables, including the quality of teaching, the character of curricular material, dominant societal conceptions of science, and students' perceptions of the cognitive demands of the subject. One of the important observations made was the waning interest in science by students as they go through secondary school, which the authors ascribed to traditional teaching methods that tend not to situate scientific principles within the daily realities of the students. Mahmood, N., & Kono, Y. (2004) administered a study on developing and validating a constructivist learner scale of science students, developed a 18-item scale with three constructs, active involvement, collaboration, and self-responsibility, each with 6 items. The instrument was proved to be reliable with 0.81 Cronbach's alpha and ecological validity. The instrument proved to be useful for teachers in measuring students' alignment with the constructivist learning paradigm. In another work by Mao et al. (2021) to investigate the association between attitudes towards science among students and their academic success in the subject, a statistically significant and moderate positive correlation was established between science achievement and attitude towards science. Of the attitude components considered, self-efficacy was found to have a stronger link with achievement compared to interest or perceived relevance to society. The research found that increasing students' self-efficacy can be an important mechanism for enhancing academic performance in science education. Additionally, a research study by Kaur and Thakur (2022) found that there was a strong positive correlation between scientific attitude and aptitude as well as students' science achievement. The researchers concluded that educational programs designed to promote scientific attitudes and increase aptitude can significantly enhance science achievement. Lieskovsky and Sunyík (2022) conducted a systematic review of recent educational interventions aimed at developing high school students' scientific reasoning abilities and attitudes towards science. The review highlighted the importance of multiple-dimensional strategies to develop scientific literacy, calling for curriculum reform and an explicit focus on building students' critical thinking capacities. Ahammad, F., & Islam, M. R.

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(2023) identified that the scientific attitude of secondary school students in Murshidabad district in West Bengal was found with noticeable differences between gender, type of school, and location. The results emphasized the importance of structured and systematic intervention to develop the scientific attitude, more so among females, urban, and private school students. The literature surveyed in aggregate points out that students' attitudes towards science have a profound impact on their academic performance in the subject.

From the review, it is concluded that there exist various interacting factors, including aptitude, relevance of the curriculum, public perception, and students' self-efficacy, which have significant roles in influencing these attitudes. In addition, the literature review calls attention to the need to nurture scientific attitudes, self-efficacy, and critical thinking through specific educational interventions and curriculum changes in order to improve both interest and achievement in science. This integration calls attention to the need to be well-versed in depth regarding the different dimensions that lead to the formation of a scientific attitude. To successfully investigate these dimensions, it becomes a necessity to conceptualize a tool for dealing with samples based on their prevailing conditions and varying needs. This provided an idea to the researcher to embark on the development of a tool and having its validity and reliability assessed so that it may be distributed and utilized by teachers and other stakeholders within classroom environments.

2. Rationale of the Study

Within the parlance of 21st-century learning and competency-based education design, development of scientific attitude among students at schools is increasingly identified as a fundamental aim of science education since scientific attitude, consisting of characteristics like curiosity, rationality, critical thinking, objectivity, open-mindedness, and an ability to translate scientific knowledge into daily life, is the corner stone of lifelong learning, wise decision-making, and civic responsibility. Though there is widespread acknowledgment of the importance of scientific attitude, there remains a scarcity of psychometrically stringent instruments that have been specifically developed to evaluate scientific attitude among school-going students in the Indian context.

The current study fills this limitation with the development and validation of a Scientific Attitude Scale (SAS) for middle and secondary school children. Based on major theoretical constructs such as curiosity, interest, rational thinking, objectivity, application of science in everyday life, and open-mindedness, the instrument is designed to offer teachers, curriculum planners, and researchers with a valid and reliable instrument for assessing the scientific dispositions of students. The instrument created in this study can play various educational roles, including assisting teachers and school administrators in determining students' attitudinal strengths and areas of science learning gaps, thus shaping differentiated instruction and customized learning plans. Furthermore, by shedding light on students' participation in science learning, the scale can assist in designing inquiry-based, hands-on, and contextually appropriate pedagogy of science. Thus, the researcher is of the opinion that this research is meaningful to the science education community in providing a context-specific, psychometrically validated instrument that benefits the larger aim of raising scientifically literate and critically thinking citizens.

3. About the Research

The current research utilized a quantitative research design focusing on the development and validation of a tool. The study was guided by a sequential exploratory design that moved from item generation, expert validation, pilot testing, statistical analysis, to final instrument validation.

4a) Research Questions

The present study seeks to answer the following research questions:

1. Can a reliable and valid Scientific Attitude Scale (SAS) be developed to assess students' attitudes toward science, with a focus on secondary-stage learners in the Indian school system?
2. And, if such a tool is developed, will it demonstrate satisfactory psychometric properties, including content validity, construct validity, and internal consistency?

4b) Objectives of the Study

The present study is guided by the following objectives:

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1. To develop a Scientific Attitude Scale (SAS) for assessing students' attitude towards science, specifically targeting secondary stage learners in the Indian classroom setting.
2. To examine the psychometric properties *(validity and reliability)* of the developed scale in order to ensure its effectiveness as a measurement tool.

4c) Hypotheses

Based on the objectives, the researcher had prepared the following testable hypotheses:-

$H_0$1: A scientific attitude scale (SAS) cannot be developed to assess students' attitude towards science, specifically targeting secondary stage learners in the Indian classroom setting.

$H_0$2: The developed scientific attitude scale (SAS) will not demonstrate satisfactory psychometric properties, including content validity, construct validity, and internal consistency.

4d) Population and Sample: The population for this study comprised secondary school students (Grades IX) from schools affiliated to the Central Board of Secondary Education (CBSE) board, India. To ensure that the sample accurately represented the larger population and captured the diversity across important student characteristics, the researcher used a **stratified random sampling method**. This approach involves dividing the population into distinct subgroups (strata) and then randomly selecting participants from each stratum. The strata used in this study included:

- Grade level: Students from secondary (Grade IX) levels of Delhi schools were included.
- Gender: Both male and female students were represented to ensure gender balance in the sample.
- Socio-economic background: Students from varied economic and social settings were included to reflect broader demographic patterns.
- Urban, Semi-urban, and Rural backgrounds: As strata of students belonging to urban and rural settings were also made.
- Academic performance: Students with differing levels of academic achievement were included to capture variability in learning and performance.

This method enabled the researcher to prepare a more representative sample, allowing for better generalization of findings across the population of CBSE secondary students.

The schools were purposively selected based on the following criteria:

1. **Geographical Location**: The schools were chosen from different localities (e.g., urban, semi-urban, and rural settings) to reflect varied socio-economic and demographic contexts.
2. **School Type**: Efforts were made to include a mix of co-educational, private, and government schools to capture diverse institutional characteristics.
3. **Willingness to Participate**: Only schools that provided consent and demonstrated willingness to facilitate student participation were included.
4. **Grade Availability**: Selected schools offered Grade IX, ensuring alignment with the defined population.

Student Distribution from Each School:

A sample of 50 students was selected from three different CBSE-affiliated Delhi schools. The relatively small sample size is consistent with the purpose of psychometric testing, particularly item analysis and reliability estimation of the tool being used. In such contexts, smaller but well-distributed samples are often considered adequate for initial validation and analysis of test items. The inclusion of students from three different schools adds variability and supports the generalizability of the results within similar school contexts. The distribution of students from different schools was as follows:

- School A (CBSE-affiliated Delhi School): 17 students (8 girls and 9 boys/ from rural setup/ Private school)
- School B (CBSE-affiliated Delhi School): 16 students (7 girls and 9 boys) (from urban setup/ Government school)
- School C (CBSE-affiliated Delhi School): 17 students (7 Boys and 10 girls) (from a semi-urban setup/government-aided school)

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This distribution ensured a balanced representation across schools while maintaining diversity. Each school provided access to student records to enable stratification, after which students were randomly selected within each stratum to form a representative sub-sample.

5. Analysis, Interpretation, and Findings

5a) Objective 1:

To develop a Scientific Attitude Scale (SAS) for assessing students' attitude towards science, specifically targeting secondary stage learners in the Indian classroom setting.

To achieve this objective, the study employed a sequential and systematic tool development process, encompassing theoretical conceptualization, item construction, expert validation, and pilot testing. The development process included the following key steps:

1. Item Construction and Conceptual Mapping

Based on the literature review and expert input, some core constructs of scientific attitude were identified. Out of the different constructs identified, 4 core constructs were shortlisted with the help of the experts.

- Curiosity and Interest in Science: This dimension assesses the extent to which students are intrinsically motivated to explore scientific phenomena, enjoy learning science, and are eager to know more about the natural world.
  - Examples of Indicators:
    - Asking questions to understand how things work.
    - Enjoying reading or watching science-related content.
    - Actively participating in experiments or science fairs.
- Rational Thinking and Open-Mindedness: This dimension reflects students' ability to reason logically, consider evidence, and remain open to changing their views in light of new scientific information.
  - Examples of Indicators:
    - Accepting scientific facts even if they contradict personal beliefs.
    - Willingness to revise opinions based on evidence.
    - Respecting diverse scientific viewpoints.
- Objectivity and Critical Thinking: This dimension measures the students' tendency to seek evidence, differentiate between facts and opinions, and approach science with a critical yet unbiased mindset.
  - Examples of Indicators:
    - Looking for proof before accepting scientific claims.
    - Analyzing various explanations before concluding.
    - Avoiding emotional or biased judgments in scientific decision-making.
- Application of Scientific Knowledge in Daily Life: This dimension captures how students apply scientific principles to real-world problems, personal decisions, and their understanding of natural and social phenomena.
  - Examples of Indicators:
    - Using science to solve everyday problems.
    - Understanding the science behind health, hygiene, and environmental practices.
    - Connecting scientific knowledge with events like natural disasters or climate change.

Each of these dimensions aligns with national educational goals outlined in:

- NEP 2020 (emphasizing scientific temper and inquiry-based learning)
- NCF 2023 (focusing on competency-based education and critical thinking)
- NCERT Learning Outcomes (promoting evidence-based understanding and application)

The first phase in the construction of the Scientific Attitude Scale (SAS) involved the generation of an initial pool of items. Each item was designed to elicit responses on a 5-point scale, with response options ranging from "Strongly Disagree" (1) to "Strongly Agree" (5). The Likert scaling was chosen for its suitability in measuring attitudinal dimensions and its widespread use in psychometric tool development. Care was taken to ensure a balanced distribution of positively and negatively worded

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statements to minimize bias. The items aimed to assess not only cognitive dispositions but also behavioral tendencies and affective inclinations toward science and scientific thinking.
For each parameter, multiple items were created to capture a range of student beliefs, behaviors, and inclinations. These items were framed as self-reported statements using simple, age-appropriate language suitable for secondary school students (Grade IX in this study). Each statement was deliberately designed as either:

- **Positive**: indicating a scientifically desirable trait or behavior (e.g., "I enjoy reading books and watching videos about science.")
- **Negative**: indicating a non-scientific or passive attitude (e.g., "I find science experiments a waste of time.")

This balanced mix of positively and negatively worded items was included to reduce response bias and encourage thoughtful reflection by the students. Items were written in the first person to promote personal reflection and emotional connection. A Likert-type scale (e.g., Strongly Agree to Strongly Disagree) was intended for responses to measure the degree of agreement or disagreement, which allows for quantitative analysis of attitudes. Items were framed to reflect everyday contexts, classroom behavior, and scientific reasoning, so as to ensure relevance and relatability. Care was taken to ensure that each item assessed only one idea or construct (unidimensional), avoiding ambiguity or double-barreled statements. Each item was cross-checked for alignment with Learning Outcomes (LOs) prescribed by NCERT, NCF 2023 themes promoting critical thinking, scientific temper, and real-life applications of knowledge, broader goals of fostering scientific attitudes, such as curiosity, objectivity, and openness to evidence.

This meticulous process ensured that the tool not only measured students' attitudes reliably but also provided insights that could inform teaching practices and curriculum interventions aimed at promoting scientific engagement among school students.
2. Expert Review: Following item development, the draft scale underwent expert review to establish its relevance and appropriateness for the target population. A panel of six subject matter experts was constituted, comprising specialists in science education, educational psychology, and psychometrics. Each expert independently reviewed the items for their clarity, linguistic appropriateness, relevance to the construct, and alignment with students' developmental level. The experts were asked to rate each item on a 4-point scale (1 = Not relevant, 4 = Highly relevant) and provide qualitative feedback for improvement. Based on their inputs, items that were deemed redundant, vague, or misaligned with the intended construct were either revised or removed.
Following this procedure, a draft of the tool with 42 items was prepared.

5b) Objective 2

To examine the psychometric properties (validity and reliability) of the developed scale in order to ensure its effectiveness as a measurement tool.

The validation of the Scientific Attitude Scale (SAS) involved both qualitative and quantitative procedures to ensure the scale's psychometric soundness. This objective was operationalized through four major stages:
i) Content Validity: Content validity refers to the extent to which a test or measurement instrument adequately represents all facets of the construct it is intended to measure. In the context of this study, content validity was essential to ensure that the Scientific Attitude Scale (SAS) reflected the comprehensive and multidimensional nature of *scientific attitude* among secondary stage school students.
To establish content validity, as discussed earlier, a panel of six subject matter experts was constituted. These experts were selected based on their academic qualifications, professional experience in the field of school education, and familiarity with psychometric tool development. The panel was provided with the initial pool of 42 items, each intended to assess one of the four identified constructs of scientific attitude. Each expert was asked to evaluate every item for:

- Relevance to the specific construct
- Clarity of wording
- Age-appropriateness for middle and secondary school students
- Absence of ambiguity or bias

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- Alignment with the objectives of science education under the National Curriculum Framework (NCF) 2023

The experts used a 4-point rating scale for relevance:

- 1 = Not relevant
- 2 = Somewhat relevant
- 3 = Quite relevant
- 4 = Highly relevant

In addition to quantitative ratings, qualitative feedback was also solicited for rephrasing, combining, or eliminating items, wherever deemed necessary. The responses were then analyzed using Lawshe's Content Validity Ratio (CVR) method, which is a widely accepted statistical technique for assessing the degree of agreement among experts regarding item relevance. The CVR for each item was calculated using the formula:

$CVR=(n_e-N/2)\div N/2$

Where:

- n_e = number of experts rating the item as "essential" (score 3 or 4)
- N = total number of experts

According to Lawshe's table of critical values, for six experts, a minimum CVR of 0.75 was required for an item to be considered valid at the 0.05 significance level. Items that did not meet this threshold were either revised based on expert comments or discarded from the scale.

Item	Experts (ne)	CVR	Action Taken
I like exploring new scientific ideas and discoveries.	6	1	Accepted
I find science experiments a big-time wastage.	5	0.67	Revised
I find science experiments either interesting or boring.	5	0.67	Revised
I enjoy reading books and watching videos about science.	6	1	Accepted
I avoid participating in science fairs or exhibitions.	6	1	Accepted
I often ask questions to understand how things work in science.	6	1	Accepted
Science is not useful in everyday life, so I don't feel like giving importance to Science experiment periods.	5	0.67	Revised
I am always excited to learn new things in my science class.	6	1	Accepted
I want to attend experiment classes and not the demo classes.	5	0.67	Revised
I believe in scientific facts, even if they go against my personal beliefs.	6	1	Accepted
I think science cannot give the base to everything, so I rely on traditional beliefs.	5	0.67	Revised
I am open to changing my opinion when new scientific evidence is presented.	6	1	Accepted
I don't blindly believe in scientists.	5	0.67	Revised
I try to find logical reasons behind every scientific phenomenon.	6	1	Accepted
I blindly trust traditional beliefs without asking about their scientific validity.	5	0.67	Revised
I respect different scientific viewpoints and try to understand them.	6	1	Accepted
I do not like it when anyone questions traditional knowledge.	5	0.67	Revised
I always look for evidence before accepting a scientific claim.	6	1	Accepted
I believe in any information related to science without checking.	5	0.67	Revised
I like to differentiate between a fact and an opinion in science.	6	1	Accepted
I think no one should question scientific facts.	5	0.67	Revised
I think emotions should not influence scientific decision-making.	6	1	Accepted
Scientific claims must match my personal beliefs.	5	0.67	Revised
I like analyzing different explanations before concluding in science.	6	1	Accepted
I enjoy testing ideas through experiments to see if they are true.	6	1	Accepted
I always try to find explanations for things that seem unusual.	6	1	Accepted
I try to use scientific principles to solve problems in my daily life.	6	1	Accepted

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I make decisions for my daily life activities not on the basis of science.	5	0.67	Revised
I try to understand the science behind natural disasters like earthquakes and cyclones.	6	1	Accepted
It hardly matters to me how science helps in solving environmental challenges.	5	0.67	Revised
I try to follow hygiene practices based on scientific knowledge.	6	1	Accepted
I believe that traditional remedies are always better than scientifically tested medicines.	6	1	Accepted

Table 2: CVR Scores

The mean CVR score for the retained items was found to be within the acceptable range, indicating a strong level of expert agreement regarding the relevance and appropriateness of the items. This rigorous validation procedure helped ensure that the final version of the Scientific Attitude Scale was conceptually sound, developmentally appropriate, and aligned with current educational standards.

As a result, the tool achieved a high degree of content validity, making it a credible instrument for assessing scientific attitude among school students in diverse educational contexts.

ii) Pilot Testing: A pilot study with 20 students ensured practical feasibility, item comprehension, and clarity. Students provided written and oral feedback post-administration.

- Observations: Minor issues in wording and layout were addressed. The scale took an average of 20-30 minutes to complete. No major difficulties were reported in understanding the items.
- Conclusion: The tool demonstrated clarity, accessibility, and logistical suitability for school settings.

iii) Item Analysis: After full-scale administration (N = 50), item-total correlation analysis was conducted. This step assessed the degree to which each item correlated with the total score of the scale, thereby identifying items that either did not align well with the overall construct or behaved inconsistently.

- Retention Criteria: Items with item-total correlation coefficients $r < 0.30$ or negative values were removed.
- Result: Approximately 32 high-performing items were retained. The retained items demonstrated moderate to strong item-total correlations, enhancing the internal coherence of the scale.

S.No.	Parameter	Item (Short Title)	Type	Item-Total Correlation	Remarks
1	Curiosity & Interest in Science	Exploring new ideas	Positive	0.62	Retain
2		Science experiments are a waste	Negative	0.41	Retain
3		Experiments are boring	Negative	0.28	Review for clarity
4		Reading about science	Positive	0.59	Retain
5		Avoid science fairs	Negative	0.33	Retain
6		Asks how things work	Positive	0.66	Retain
7		Science is not useful in daily life	Negative	0.27	Needs revision
8		Excited to learn new things	Positive	0.69	Retain
9		Prefers experiment classes	Positive	0.38	Retain
10	Rational Thinking & Open-Mindedness	Believes in scientific facts over personal beliefs	Positive	0.52	Retain
11		Relies on traditional beliefs	Negative	0.29	Review for clarity

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12		Open to new scientific evidence	Positive	0.63	Retain
13		Doesn't believe the scientist's statements	Negative	0.31	Retain
14		Finds logic in phenomena	Positive	0.70	Retain
15		Blindly follows tradition	Negative	0.22	Needs revision
16		Respects scientific viewpoints	Positive	0.58	Retain
17		Opposes science challenging tradition	Negative	0.35	Retain

Table: Glimpse of Item analysis carried out for the validation

iv) Reliability Analysis

The internal consistency of the scale was evaluated using Cronbach's Alpha (α) coefficient:

- For the overall scale, α = 0.83, indicating high reliability.
- For the four subscales:
    - *Curiosity and Interest in Science*: α = 0.81
    - *Rational Thinking and Objectivity*: α = 0.78
    - *Critical Thinking and Open-mindedness*: α = 0.74
    - *Application of Scientific Knowledge in Daily Life*: α = 0.76
- Interpretation: All subscales exceeded the commonly accepted reliability threshold of α ≥ 0.70, confirming internal consistency across constructs.

v) Ethical Considerations: The study adhered to ethical research practices. Consent was obtained from school authorities and, where necessary, from parents/guardians. Participants were informed of their right to withdraw at any point, and all data were used strictly for research purposes.

vi) Limitations: While the scale was rigorously developed, potential limitations include:

- Restricted generalizability due to region-specific sampling (only to Delhi)
- Self-reported responses may be subject to social desirability bias

6. **Major Findings**

- The content validation process confirmed high relevance and clarity of the items, supported by strong CVR scores.
- The item analysis eliminated non-performing items, ensuring each item contributed positively to the construct being measured.
- The Cronbach's alpha values demonstrated strong internal consistency for both the entire scale and its sub-dimensions.
- The factor analysis revealed a stable and interpretable structure aligned with the theoretically defined constructs, verifying the scale's construct validity.

Hypotheses Testing

$H_0 1$: A scientific attitude scale (SAS) cannot be developed to assess students' attitude towards science, specifically targeting secondary stage learners in the Indian classroom setting.

As the researcher, under the guidance and expertise of the guide and experts, could develop the scientific attitude scale (SAS), the null hypothesis is **rejected.**

Dimensions	Items	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Curiosity & Interest in Science	I like exploring new scientific ideas and discoveries. I find science experiments time-consuming.					

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	I enjoy reading books and watching videos about science.					
	I wish to contribute and add value to the field of Science.					
	I avoid participating in science fairs or exhibitions.					
	I often ask questions to understand how things work in science.					
	I find less applicability of Science in everyday life, so I get less engaged during the Science experiment periods.					
	I am always excited to learn new things in my science class.					
	I want to attend more of the experiment practice classes than the demo classes.					
Rational Thinking & Open-Mindedness	I believe in scientific facts, even if they go against my personal beliefs.					
	I think science cannot explain many things, so I rely on traditional beliefs.					
	I am open to changing my opinion when new scientific evidence is presented.					
	I do not believe something just because a scientist says it.					
	I blindly follow traditional beliefs without questioning their scientific validity.					
	I respect different scientific viewpoints and try to understand them.					

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	I do not like it when people challenge traditional knowledge with science.					
Objectivity & Critical Thinking	I believe in any information related to science without checking if they are true.					
	I like to differentiate between a fact and an opinion in science.					
	I think questioning scientific facts is a waste of time.					
	I think emotions should not influence scientific decision-making.					
	I trust scientific claims only if they match my personal beliefs.					
	I like analyzing different explanations before concluding in science.					
	I enjoy testing ideas through experiments to see if they are true.					
	I always try to find explanations for things that seem unusual.					
Application of Scientific Knowledge in Daily Life	I try to use scientific principles to solve problems in my daily life.					
	Science is not the basis of my decisions I take for my daily life activities.					
	I try to understand the science behind natural disasters like earthquakes and cyclones.					

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	I do not care about how science helps in solving environmental problems.					
	I try to follow hygiene practices based on scientific knowledge.					
	I believe that traditional remedies are always better than scientifically tested medicines.					
	I recognize the importance of science in making life better.					
	I do not give up when my science experiment fails.					
	I get frustrated easily when I do not get quick results in a science project.					
	I am patient while conducting experiments and recording observations.					
	If I don't understand a scientific concept quickly, I believe it blindly.					
	I believe that repeated trials are necessary to confirm scientific findings.					
	I find it boring to take time to observe and analyze scientific data.					
	I understand that scientific discoveries require hard work and patience.					

Table 1: Final Draft of the Constructed Tool

H_02: The developed scientific attitude scale (SAS) will not demonstrate satisfactory psychometric properties, including content validity, construct validity, and internal consistency.
This null hypothesis was also **rejected** as the items in the scale were perceived as relevant and representative of the construct of scientific attitude.

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- The calculated CVRs for the majority of items were **above 0.75**, indicating strong content validity.
    - The study employed a panel of six experts who rated each item for relevance using a 4-point scale.
    - The Content Validity Ratio (CVR) was computed for each item using Lawshe's method.
    - Items with CVR ≥ 0.75 were retained.
    - The final retained items were grouped under four clearly defined constructs.
    - EFA was conducted to confirm that these items clustered under the expected dimensions.
- As the factor loadings were strong and aligned with the proposed structure, the null hypothesis was **rejected**, confirming **construct validity**.
    - The overall Cronbach's alpha was **0.83**.
    - Subscale alphas ranged from **0.74 to 0.81**, all exceeding the minimum accepted value of 0.70.
    - These values indicate high internal consistency, leading to **rejection** of the null hypothesis.

The results of the study support the rejection of both null hypotheses, thereby confirming that the Scientific Attitude Scale (SAS) is a psychometrically sound instrument suitable for assessing various attitudinal dimensions in the school context, and its findings are generalizable within similar CBSE-affiliated educational settings.

7. Conclusion

The research consisted of thorough stages such as item development, content validation based on experts, pilot testing, item analysis, reliability tests, and construct validation. The scale showed good psychometric characteristics with high internal consistency (Cronbach's alpha > 0.80) and good content and construct validity, ascertained through expert ratings. The results also highlight that scientific attitudes among students are multi-dimensional and that they can be assessed reliably through a standardized Likert-type instrument. The scale provides a relevant diagnostic instrument that captures the curricular aspirations of today, specifically those presented in the National Education Policy (NEP) 2020 and the National Curriculum Framework (NCF) 2023, such as scientific literacy, critical thinking, and inquiry-based learning.

Thus, the research not only achieves its intended purpose but also adds a useful instrument for research, evaluation, and educational planning in the Indian school education system.

8. Educational Implications

- For Teachers and Schools: The SAS may be used as a diagnostic measure to evaluate students' orientations towards science, so that teachers can design pedagogical approaches to encourage inquiry, curiosity, and evidence-based thinking. Teachers may identify learners with lower scientific attitude scores and administer targeted interventions to improve their uptake of scientific learning.
- For Curriculum Developers: The empirically validated scales of scientific attitude can be used to shape curricular design and instructional materials. By incorporating activities that cultivate curiosity, rationality, and receptivity to evidence, textbooks and instructors' guides can better fit within competency-based education.
- For Educational Planning and Policy: Since the instrument is consistent with national guidelines such as NEP 2020 and NCF 2023, it provides a ready-to-use instrument for systemic monitoring and assessment of the scientific temper development of school children. It lends strength to policy-level goals to develop scientifically aware and critically thinking citizens.
- For Teacher Educators and Researchers: The SAS offers a validated measure for future research on student motivation, science achievement, and the effectiveness of pedagogical interventions. It can also be applied in pre-service and in-service teacher education programs to investigate how teacher practices shape students' attitudes toward science.

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- For Students: Reflection on items in the SAS can facilitate metacognitive consciousness regarding one's own orientation towards science and thus facilitate self-regulated learning and scientific thinking growth.

9. Limitations and Suggestions for Future Research

Although the SAS is psychometrically sound, the researcher would like to bring to the notice the following study limitations:

- The sample was relatively small and geographically localized, and as such might have constrained generalizability.
- The responses were self-reported and as such might be subject to social desirability bias.
- The investigation was restricted to CBSE secondary school students only; extension of validation across regional boards and varied cultural settings is advocated.

Suggestions for future studies:-

- Investigate longitudinal uses of the SAS to monitor change in scientific attitude across time.
- Examine relationships between SAS scores and academic performance, inquiry competence, and STEM career orientation.
- Translate and validate the instrument in local languages to provide broader usage across Indian school systems.

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