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ARTICLE

Science Literacy among Secondary & Post-Secondary Students: A Study of Hyderabad-based Schools

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ABSTRACT

This research explores the extent of science literacy among the students of secondary and post-secondary levels through a set of questions standardised and validated for the purpose. The study also considers the possible difference in science literacy levels on some of the basic demographic variables and the scheme of syllabus followed by the school.

This research is based on primary data collected from a sample of 823 students studying 10^{th}-11^{th} standards from select schools in Hyderabad.

The analysis of the survey data indicates the following:

- On the whole, science literacy is low among the respondents. This, despite high cognitive level questions not being used in the test;
- Analysis of data on demographic variables shows that boys tend to be significantly better at science literacy scores;
- Also, age has a significant impact on science literacy (those who are 15 years old fare better);
- Students attending private schools show a significantly better science literacy score. This is probably due to over-emphasis on grades in private schools;
- Students of those schools following the ICSE, and CBSE syllabi as opposed to the Telangana State syllabus for studies score significantly better on science literacy;
- Learning deficits during the COVID years may have affected science literacy performance among the respondent group.

KEYWORDS: Science Literacy, Secondary Education, Post-secondary Education

Science literacy, in a general sense, has become synonymous with understanding science by the public. It calls for a functional understanding of science for purposes of general education and not necessarily to prepare for specific scientific and technological careers. It is also not a fundamental cultural tool that is comparable to the 3Rs — Reading, Writing and Arithmetic. The phrase is used somewhat metaphorically and goes beyond mere reading and writing (Hurd, 1998& Klein, 2006) and the goals of science education can be expressed as scientific literacy (Norris & Phillips, 2003).

OECD (2006), in its report on the topic, observes that the main goal of science education is to enable students to use scientific concepts and methods to address problems in research, professional practice, and daily life. Lazonder and Harmsen (2016) argue that an understanding of the scientific method is seen as necessary to engage in inquiry learning. So much so, science literacy becomes a part of science education needed for civic engagement (Rudolph & Horibe, 2015) and a vital part of preparing the workforce.

It is true that to master and survive in this technology-driven world, skills of critical thinking, problem-solving, and creative & innovative communication are essential, among others. And, to master technology fluently, excellent scientific literacy skills are required. An individual with excellent scientific literacy skills could think, behave scientifically, be curious, develop social-environment sensitivity, and use science disciplines to solve problems (Graber *et al.*, 2001; Holbrook & Rannikmae, 1997; Laugksch, 2000; National Research Council, 1996; OECD, 2003; OECD 2007.

Today's world calls for understanding science in essential terms because

- Everyone needs to use scientific information to make choices that arise every day
- Everyone deserves a share in the excitement that can come from understanding and learning about the natural world
- Everyone needs to be able to engage intelligently in public discourse and deliberate about important issues that involve science & technology

- Today's jobs require that people be able to learn, reason, think creatively, make decisions and solve problems; and also to become capable citizenry (National Research Council (US)), 1996.

National Science Teachers' Association (NSTA) of the USA, identified science literacy as the “relationship between science and society”. Scientifically literate person was one who “uses science concepts, possess skill and values in making everyday decisions as he interacts with other people and with his environment and understands the interrelationship between science, technology and other facets of society, including social and economic development” (NSTA, 1971).

The term scientific literacy and its associated meaning have evolved over the last several decades and have not always meant the same (By bee, 1997). At the school level, the concept and its definition sum up the intention of science education.

Scientific literacy means that a person can

- Ask, find, or determine answers to questions derived from curiosity about everyday experiences
- Read with understanding articles about science in the popular press
- Identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed
- Evaluate the quality of scientific information on the basis of its source and the methods
- Acquire the ability to describe, explain, and predict natural phenomena
- Develop the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately (National Research Council. 1996 p. 22).

At the school level, By bee (1997) suggested that science literacy can be considered at 4 levels

1. Nominal — recognise scientific terms
2. Functional — can use scientific and technological vocabulary

3. Conceptual/procedural — demonstrates understanding
4. Multi-dimensional — has a development perspective of S&T.

Several methods are used to assess scientific literacy, and there are several tools for the same — Aiken head & Ryan (1992); Champagne *et al.* (2000), Korpan CA *et al.*(1994), Laugksch & Spargo (1996) have attempted different methods for evaluating science literacy. The test format has continuously evolved in its science literacy measures. (Tsabric Yarden, 2005; Schleicher, A, 1999; Tsabari & Yarden, 2005)

Optiz *et al*. (2017) analysed 38 tests, 11 of which developed between 1973 and 1989, and 27 between 2002 and 2013. The main target audience was secondary school students. Of the 258 skill descriptions identified in the tests, 218 related to eight main reasoning skills, and 40 were grouped into the 'others' category. Skills included in the tests were — problem identification, questioning, hypothesis generation, evidence generation, evidence evaluation, drawing conclusions, communication and scrutinising, and others. Most tests had multiple choices, and a few others had mixed question formats, open-ended questions, or other formats.

After considering various tests, the authors (Opitz *et al.* 2017) argue that there has been a shift from assuming scientific reasoning to be unidimensional ability to one that treats it as multidimensional. This multidimensional structure involves problem-solving activities in which several skills must be orchestrated. In recent years, it is OECD's Programme of International Student Assessment (PISA) that we get to read in the context.

PISA framework (OECD, 2007) differentiates between the three skills of identifying scientific issues, explaining phenomena scientifically, and using scientific evidence, but also combines their scores into a single science scale. Thus, the four most commonly tested scientific reasoning skills are hypothesis generation, evidence generation, evidence evaluation and drawing conclusions.

The programme expects that the learners acquire scientific reasoning skills, and engage in scientific discussion as a crucial part of science education.

PISA 2006 defines scientific literacy as Knowledge of science and Knowledge about science. The 2015 PISA definition of scientific literacy (OECD, 2013) is the ability to engage with science-related issues with the ideas of science as a reflective citizen. A scientifically literate person, therefore, is willing to engage in a reasoned discourse about science and technology, which requires the following competencies:

***Explain phenomena scientifically*:** Recognise, offer, and evaluate explanations for a range of natural and technological phenomena, demonstrating the ability to

- Recall and apply appropriate scientific knowledge
- Identify, use and generate explanatory models and representations
- Make and justify appropriate predictions
- Offer explanatory hypotheses
- Explain the potential implications of scientific knowledge for society

***Interpret data and evidence scientifically*:** Analyse and evaluate data, claims and arguments in a variety of representations and draw appropriate scientific conclusions demonstrating the ability to

- Transform data from one representation to another
- Analyse and interpret data and draw appropriate conclusions
- Identify the assumptions, evidence and reasoning in science-related texts
- Distinguish between arguments which are based on scientific evidence and theory and those based on other considerations
- Evaluate scientific arguments and evidence from different sources (eg. newspapers, journals, internet, etc.)

***Evaluate and design scientific inquiry*:** Describe and appraise scientific investigations and propose ways of addressing questions scientifically demonstrating the ability to

- Identify the question explored in a given scientific study
- Distinguish questions that are possible to investigate scientifically
- Propose a way of exploring a given question scientifically
- Evaluate ways of exploring a given question scientifically

- Describe and evaluate a range of ways that scientists use to ensure the reliability of data and the objectivity and generalisability of explanations.

Central Board of Secondary Education

CBSE (2019) defines Scientific Literacy as "The capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions to understand and help make decisions about the natural world and the changes made to it through human activity."

Scientific literacy means that a person:

- Can ask, find, or determine answers to questions derived from curiosity about everyday experiences.
- Has the ability to describe, explain, and predict natural phenomena.
- Can read with understanding, articles about science in the popular press and to engage in social conversation about the validity of the conclusions.
- Can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed.
- Can evaluate the quality of scientific information based on its source and the methods used to generate it.
- Has the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately.

The framework adopted by CBSE conforms to PISA's understanding of the concept. The CBSE's efforts are to measure up to the international standards in the coming years and fare better in science literacy tests like the PISA.

The available data indicate that Indian science literacy is far below the international level. This means the students are unable to apply and analyse the concepts to solve a problem. Students tend to memorise the concepts but fall short in using knowledge (Sharma, 2019).

Objectives of the study

The present study attempts to understand science literacy levels among school students. Specifically, the study explores the extent of science literacy among the students of secondary and post-secondary levels through a set of questions standardised and validated for the purpose. The study also explored the possible difference in science literacy levels on some of the basic demographic variables and the scheme of syllabus followed by the school.

Methodology

This research is based on primary data collected from secondary and post-secondary level students from selected schools in Hyderabad. The sample was drawn from students studying in 10^{th}-11^{th} standards. This narrowed the age gap and the resultant cognitive level difference among the respondents. Data were collected from September to December 2022.

To begin with, several schools were approached for data collection. Consultation with school principals as to the nature of student competency was taken note of in the process. The final selection of the sample was based on schools which attracted different brackets of students. This ensured the respondents fell in different levels of academic competence. Finally, eight schools that fell into the categories preferred by the students of various socio-economic categories and competence levels were identified. Broadly, these belonged to the categories (as mentioned by the school authorities and popular perception shared by the wider public) such as less preferred, average, and elite schools, which have varying student selection criteria. They belonged to both government and private school categories. However, it was noticed that the facilities did not vary much across the schools. From each school which participated in this study, about 100 students made up the sample.

The study population of 10^{th} standard students comprised 607, as they were the primary focus and science literacy measure was pitched at that level. Eleventh-class students mostly study in a separate category of pre-college institutions in Telangana State. Two popular ones in the category — Chaitanya Junior College and Narayana Junior College — were approached, and a random pick of 216 students with science backgrounds formed the respondent group. The data was not analysed for inter-school comparisons.

The study was post-facto research based on a structured questionnaire. The questionnaire was self-administered by the respondents. Prior to handing over the research instrument, the students were briefed about the research objective, and its non-evaluative nature was highlighted. To ensure this, the students' names were not elicited in the instrument. The students took the science literacy test in their class hours. Students generally took one hour to complete the entire questionnaire. The survey included student age (year of birth) and gender. The syllabus followed for the studies was also a part of the questionnaire.

Pilot Survey

Pilot survey in the context was the first level validation. Pilot survey of the instrument was conducted in two schools with a sample of 50 students. The pilot intended to ascertain the distribution of the response categories in scale items and the homogeneity and discrimination potential of the response distribution for the scale items. The pilot was also used to learn about the difficulty level of the questions in science literacy and the average time it would take to respond to the entire instrument.

The science literacy questions in the pilot included all three difficulty levels, namely those in high (analyse complex information or data; synthesise or evaluate evidence; justify; reason, given various sources; develop a plan or sequence of steps to approach a problem), medium (use and apply conceptual knowledge to describe or explain phenomena, select appropriate procedures involving two or more steps, organise/display data, interpret or use simple data sets or graphs) and low (carry out a one-step procedure, for example recall a fact, term, principle or concept, or locate a single point of information from a graph or table) cognition. The definitions of the cognitive difficulty levels are suggested by OECD, and PISA (OECD, 2017).

The response indicated that despite questions coming from similar tests (scales critically reviewed before the finalisation of method included PISA, California Critical Thinking Disposition Inventory, Scientific Inquiry Competency Test, Modified 27-item Chinese Version of Critical Thinking Scale, etc.). Invariably students could not respond correctly to high cognitive level questions. There was no exception to this trend.

Questionnaire preparation

The science literacy measure finalised based on the pilot survey outcome, had eight main questions and the varying number of sub-questions. In all there were 21 items. They included multiple choice, Yes or No, and also one fill-in-the-blank type questions. The questions expected students to accomplish simple calculations, spot the correct graph to represent the given data, spot the evidence or a possible hypothesis, etc. The questions were in low and medium cognitive levels and the students were expected to choose the right answers. Low cognitive questions were given weight (marks) 1 and the medium cognitive level questions 2 in computing the science literacy total scores. In all the maximum a student could obtain were 33 marks. No student complained about comprehension of the science literacy questions. The final response comprised 400 boys (48.6%) and 423 girls (51.4%). They fell into the age ranging from 14-17 years (Table 1).

Table 1: Gender-wise distribution of respondents

Gender	Frequency	Percent
Boys	400	48.6
Girls	423	51.4
Total	823	100.0

Table 2: Age-wise distribution of respondents

Age in Years	Frequency	Percent
17	121	14.7
16	112	13.6
15	419	50.9
14	171	20.8
Total	823	100.0

Statistical analysis

The filled-in questionnaires were initially scrutinised for their completeness and were followed by tabulation and analysis using SPSS (Statistical Package for Social Science) software. The statistics used for various analyses included Frequency distribution and percentages, t-statistics, and one-way ANOVA (Analysis of Variance).

Results and Discussion

To begin with, the responses for the science literacy measure were validated with three different measures, namely t-statistics, difficulty index, and discrimination index of the questions. The difficulty index is calculated by dividing the number of respondents getting the answers correct by the total sample. The discrimination index is calculated by considering the total science literacy score of the respondents and the number of high and low-achiever groups getting correct answers to the question. In our context, as no one was in the very high group, high and very low groups were considered for the analysis. T-statistics was also computed to measure the conventional discrimination capacity of the questions. For this purpose, Q1 and Q3 groups based on the total science literacy scores were considered to understand the statistical significance of the correct/incorrect responses of the two groups.

Based on all three criteria, the question's appropriateness in the measure was reconfirmed. When the criterion is very low, or the t ratio is not significant, the question in the context may not discriminate between high and low science literacy achievers.

All the questions in the science literacy measure have significant t value and validate their ability to differentiate different groups. This is a conventional measure. The measure is valid, passes the statistical test in the field condition, and could be used for other similar surveys in our context (Table 3).

After establishing the validity of the measure the analysis was taken forward by computing total science literacy scores for the respondents. The test had 21 questions, 9 of which were categorised as low cognition and 12 as medium cognition. The test deliberately excluded questions with high cognition levels as the pilot test

Table 3: Summary of the science literacy test administered

Q. No.	Description of the Question	Skills Expected	Cognitive Level	Response Format	Difficulty Index	Discrimination index	t value *df=428* **p<.05* ***p<.01*	Criteria based on different statistical tests
1	Identify the correct graph representing the data given	Communication & Scrutiny	Low	Multiple choice	0.36	0.37	*4.997***	**Moderate**
2	Identify good location for a windmill for power generation based on the given graphical data of wind pattern	Evidence Evaluation	Medium	Multiple choice	0.68	0.67	*4.772***	**Good**
3	Verify the math formula to arrive at the explained sum	Basic math scrutiny	Low	Yes/No	0.25	0.26	*4.1 ***	**Moderate**
4	Verify the math formula to arrive at the explained sum	Basic math scrutiny	Low	Yes/No	0.38	0.38	*2.300 **	**Moderate**
5	Verify the math formula to arrive at the explained sum	Basic math scrutiny	Low	Yes/No	0.24	0.21	*0.253*	**Moderate**

(Contd.)

Table 3: Summary of the science literacy test administered

Q. No.	Description of the Question	Skills Expected	Cognitive Level	Response Format	Difficulty Index	Discrimination index	t value *df=428* **p<.05* ***p<.01*	Criteria based on different statistical tests
6	Verify the math formula to arrive at the explained sum	Basic math scrutiny	Low	Yes/No	0.61	0.59	*3.828* **	**Good**
7	Validate the statement based on the given scientific text	Drawing conclusion	Medium	Yes/No	0.57	0.59	*5.862* **	**Good**
8	Validate the statement based on the given scientific text	Drawing conclusion	Medium	Yes/No	0.66	0.67	*4.384* **	**Good**
9	Validate the statement based on the given scientific text	Drawing conclusion	Medium	Yes/No	0.45	0.4	*0.680*	**Good**
10	Validate the statement based on the given scientific text	Drawing conclusion	Medium	Yes/No	0.64	0.64	*5.717* **	**Good**

(*Contd.*)

Table 3: Summary of the science literacy test administered

Q. No.	Description of the Question	Skills Expected	Cognitive Level	Response Format	Difficulty Index	Discrimination index	t value *df=428* **p<.05* ***p<.01*	Criteria based on different statistical tests
11	Arrive at a conclusion based on explained conditions	Drawing conclusion	Low	Multiple choice	0.36	0.39	*7.484* **	**Moderate**
12	Indicate the probable visual image in an explained imaginary situation	Others	Low	Multiple choice	0.53	0.5	*3.799* **	**Good**
13	Comprehend scientific text and, based on that spot, the correct conclusion	Drawing conclusion	Medium	Multiple choice	0.49	0.49	*7.834* **	**Good**
14	Identify the correct graphical representation to elicit the explained data	Communication & Scrutiny	Low	Multiple choice	0.35	0.32	*2.372* *	**Moderate**
15	Spot the appropriate reason for a scientific phenomenon	Evidence Evaluation	Medium	Multiple choice	0.35	0.32	*4.089* **	**Moderate**
16	Spot the correct problem that could be scientifically examined	Hypothesis generation	Medium	Multiple choice	0.29	0.33	*7.341* **	**Moderate**

(*Contd.*)

Table 3: Summary of the science literacy test administered

Q. No.	Description of the Question	Skills Expected	Cognitive Level	Response Format	Difficulty Index	Discrimination index	t value *df=428* **p<.05* ***p<.01*	Criteria based on different statistical tests
17	Spot the commonly known scientific principle in action	Drawing conclusion	Low	Multiple choice	0.37	0.42	*7.45* **	**Good**
18	Observe and understand the details in a graph and identify the correct hypothesis in the context from the list	Hypothesis generation	Medium	Multiple choice	0.31	0.35	*3.1* **	**Moderate**
19	Spot the statement which can help generate valid scientific evidence	Evidence generation	Medium	Multiple choice	0.21	0.22	*3.24* **	**Moderate**
20	Spot the valid scientific argument from the list	Evidence evaluation	Medium	Multiple choice	0.27	0.29	*9.092* **	**Moderate**
21	Based on a formula given explain what happens if the values of some of its elements are altered as stated	Drawing conclusion	Medium	Fill in the blank	0.24	0.25	*8.202* **	**Moderate**

indicated that students invariably found it difficult to respond correctly. This view was also endorsed by science teachers at the secondary level. Nonetheless, there is a need to equip our students to cope with the high cognition level questions to enable them to be fully science literate comparable to the international level.

Total science literacy scores were compiled by allotting 1 mark each to correct Low Cognition questions and 2 marks to the Medium cognition ones. The possible science literacy scores ranged from 0 to 33. The possible theoretical scores were divided into five different levels for identifying the relative science literacy of the group as follows:

0-7 Very low; 8-14 Low; 15-21 Average; 22-28 High; and 29 and above Very high.

The observed science literacy score ranged from 0-26.

The distribution of respondents in the above categories was as follows:

Table 4: Frequency distribution Science literacy statistics for the group

N	823
Mean	13.48
Std. Deviation	4.704
Minimum	0
Maximum	26

Table 5: Frequency and distribution of respondents on different science literacy scores

Sc. Lit. Score	Frequency	Per cent
0	2	0.2
2	1	0.1
3	4	0.5
4	6	0.7
5	20	2.4
6	22	2.7
7	32	3.9
8	41	5.0
9	44	5.3
10	57	6.9

Sc. Lit. Score	Frequency	Per cent
14	53	6.4
15	72	8.7
16	51	6.2
17	47	5.7
18	56	6.8
19	36	4.4
20	24	2.9
21	20	2.4
22	16	1.9
23	13	1.6

11	71	8.6	24	6	0.7
12	54	6.6	25	4	0.5
13	69	8.4	26	2	0.2
			Total	823	100.0

Table 6: Frequency distribution of High, Medium and Low Science Literacy groups

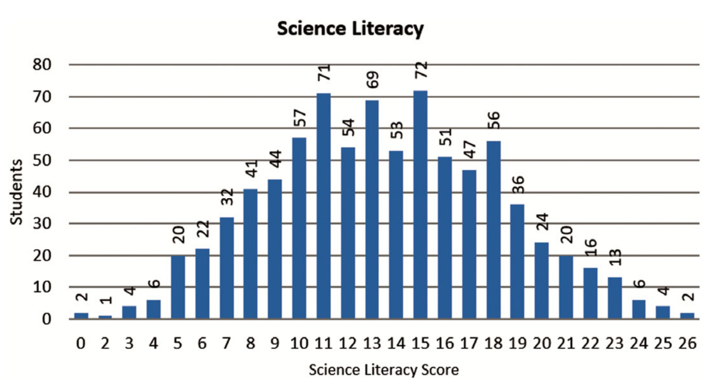
	Frequency	Per cent
Very Low	87	10.6
Low	389	47.3
Average	306	37.2
High	41	5.0
Very High	0	0.0
Total	823	100.0

The results show that science literacy level is relatively low in the age group 15-17. Given that the high cognition questions were excluded from the test, the real PISA-like test would result in very low performance.

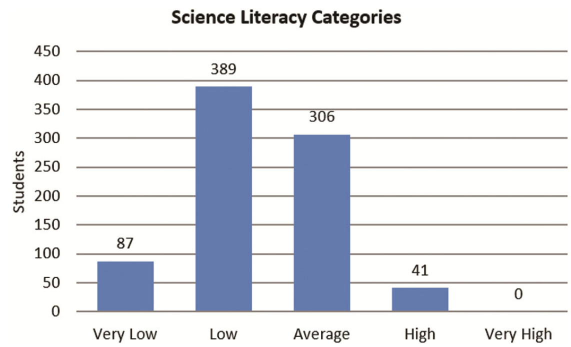
In this context, it could be mentioned that the standard of this measure was appropriate as students did not get all the questions correct.

The Graphs corresponding to the total score are presented below.

Graph 1: Distribution of respondents on total science literacy scores



Graph 2: Distribution of respondents on science literacy groups



Science literacy data were analysed to examine how the criterion variable differed across the demographic variables in the study.

The respondents were distributed more or less equally between boys (48.6%) and girls (51.4%). The study had 50% of the respondents born in 2007 (15 years at the response time), and 171 respondents (20.8%) were born in 2008 but were studying 10^{th} standard. The higher age bracket respondents (born in 2005, 2006) mostly represented post-secondary (11^{th} standard) students who comprised 28% of the total. The sample was drawn from eight different schools, which included both government and private ones. They followed varying syllabi for teaching, such as CBSE, ICSE, and Telangana State-prescribed ones. The distribution of the participants according to these criteria is presented in the Tables below.

The analysis for three of these variables was confined to respondents studying 10^{th} class as the syllabus followed by 11^{th} standard students did not matter as what they studied differed. Also, the 11^{th} standard student sample was drawn from intermediate colleges, and the ATL scheme did not apply to them.

Gender *vs* Science literacy

The data on the distribution of science literacy scores across boys and girls in the respondent groups were analysed to explore whether there is a statistically significant difference between them. ANOVA statistics show a significant difference between these two groups on science literacy (F=4.300 p<. 041). Boys tend to score higher in science literacy. (Table 7 (a) (b)).

Table 7 (a): Frequency, Mean, SD of Science Literacy for Gender groups

		N	Mean	Std Deviation
Science Literacy	Boys	400	13.82	4.762
	Girls	423	13.15	4.631
	Total	823	13.48	4.704

(b) ANOVA Summary — Gender vs Science Literacy

		Sum of Squares	df	Mean Square	F	Sig.
Science Literacy	Between Groups	92.582	1	92.582	4.200	.041
	Within Groups	18096.657	821	22.042		
	Total	18189.239	822			

Age

The respondents came from agesranging from 15 to 17, as the study covered both 10th and 11th standards. Those born in 2007 (15 years at the time of the survey) made up slightly more than 50% of the total (Table 8). Analysis of innovativeness data for different ages reflects non-significant statistical relations ($F=1.446$ NS) and a significant one for science literacy ($F = 16.689$ $p <.000$). Post hoc analysis of science literacy distribution shows that those who are 15 years old tend to different significantly from those in the other age. Being of the right age and in the right class seems to make a difference.

Table 8 (a): Frequency, Mean, SD of Science Literacy for Age groups

Age	N	Mean	Std. Deviation
17	121	12.10	4.447
16	112	11.77	4.018
15	419	14.52	4.818
14	171	13.01	4.388
Total	823	13.48	4.704

(b) ANOVA Summary — Age vs Science Literacy

		Sum of Squares	df	Mean Square	F	Sig.
SCLIT_TOTAL	Between Groups	1047.873	3	349.291	16.689	.000
	Within Groups	17141.367	819	20.930		
	Total	18189.239	822			

School Type

The students in the survey came from both public and private schools (Table 9). The ANOVA shows significant differences in science literacy across the school types. Private school respondents, who made up a substantial chunk of the sample, seem significantly better than the students in government schools. The trend is very pronounced in science literacy with F Ratio = 86.901 p<.000. The study, however, had a smaller representation from government schools, which may have a bearing on the outcome.

Table 9 (a): Frequency, Mean, SD of Science Literacy for Age groups

School type	N	Mean	Std. Deviation
Private	521	14.70	4.506
Public	86	9.91	3.849
Total	607	14.02	4.723

(b) ANOVA Summary — School type vs Science Literacy

		Sum of Squares	df	Mean Square	F	Sig.
SCLIT_TOTAL	Between Groups	1697.535	1	1697.535	86.901	.000
	Within Groups	11818.143	605	19.534		
	Total	13515.677	606			

Syllabus followed

Respondent groups belonged to schools following the different syllabi, namely Telangana State Syllabus, CBSE, and ICSE. The science literacy syllabus shows a significant F Ratio (Table 10). Science literacy scores are significantly high for those following ICSE, followed by CBSE and Telangana State Syllabus in that order. On enquiry about this trend, teachers confirmed that the

State syllabus is no less in comparison and could be even better on recommended activities and the topics studied.

Table 10 (a): Frequency, Mean, SD of Science Literacy for Syllabus followed groups

	N	Mean	Std. Deviation
State	200	11.64	4.287
CBSE	71	13.52	4.039
ICSE	336	15.55	4.499
Total	607	14.02	4.723

** 11th standard students in the study did not follow the overlapping syllabus as they studied at a higher level and were excluded from this analysis.*

(b) ANOVA Summary — School type vs Science Literacy

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1934.641	2	967.320	50.450	.000
Within Groups	11581.036	604	19.174		
Total	13515.677	606			

Thus, the analysis of demographic variables shows interesting variations and seem to weigh better for private schools, those belonging to 15 years of age, and those following state syllabus for learning the subjects. All these seem to matter in the context and reflect varying advantages, but not in a consistent manner *vis-a-vis* science literacy.

Science literacy distribution — Low and Medium cognitive levels

It was also explored whether respondents' science literacy would be better if the questions were confined to low cognition questions only. By the distribution of scores on low and medium cognition questions independently, it could be seen that the distribution of the group on low cognition questions is normal and those on moderate cognition are skewed when we consider the theoretical range. The mean of low cognition questions at 3.27 is near the theoretical mid-point of 4.0 than for medium cognition items with an observed mean of 10.20 against the theoretical mid-point of 12.00.

Table 11 (a): Science literacy distribution — Low and Medium cognitive levels

Low cognitive question

N	823
Mean	3.2685
Std. Deviation	1.64326
Minimum	.00
Maximum	8.00

Science Literacy–Low cognition questions

Score	Frequency	Percent
0	24	2.9
1	103	12.5
2	152	18.5
3	190	23.1
4	155	18.8
5	125	15.2
6	55	6.7
7	14	1.7
8	5	0.6
Total	823	100.0

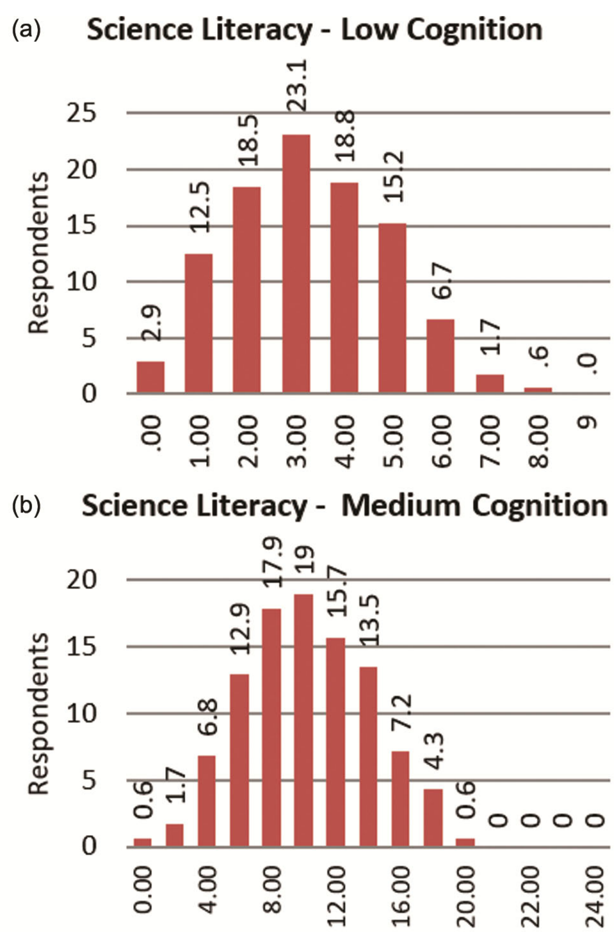
(b) Medium cognitive question

n	823
Mean	10.2066
Std. Deviation	3.94871
Minimum	0
Maximum	20

Science Literacy – Medium cognition questions

Scores	Frequency	Percent
0	5	0.6
2	14	1.7
4	56	6.8
6	106	12.9
8	147	17.9
10	156	19
12	129	15.7
14	111	13.5
16	59	7.2
18	35	4.3
20	5	0.6
21	0	0
22	0	0
23	0	0
24	0	0
Total	823	100

Graph 3: Science literacy distribution for Low and Medium cognitive level questions



The analysis was taken forward by considering the low- and medium-level cognition responses separately. The distribution of responses indicates a greater tendency among the group to get the low cognitive level items correct than the medium cognitive level ones. However, they are not exclusive categories. There is every chance of respondents getting the medium cognition level question correct and missing the low cognitive ones. The distribution, on the whole, shows that the categorisation of the science literacy questions in the two levels is correct. The distribution on the medium cognition level questions is skewed towards the lower end, and no one has gotten completely correct. Perhaps learning deficiency during COVID years could be an explanation for the shortfall.

What do the results imply?

The data and the statistical analysis indicate the following:

Science literacy

- The science literacy measure used in the survey is valid, viewed in terms of its discrimination index, difficulty index, t values, cognitive difficulty level, and science literacy skills adopted to verify the soundness of the measure.
- On the whole, science literacy is low among the respondents. This is despite high cognitive level questions not being used in the test.

Demographics

- Data analysis on demographic variables shows boys are significantly better at science literacy scores.
- Also, age has a significant impact on science literacy (those who are 15 years old fare better).

School and syllabus

- Students attending private schools show a significantly better science literacy score. This is probably due to over-emphasis on grades in the private schools.
- Students of those schools following ICSE and CBSE syllabi as opposed to the Telangana State syllabi for studies score significantly better on science literacy.
- Prescribed NCERT science textbooks include main content with high readability, for the age group. These textbooks also have highlighted contents such as 'Activities', 'Think it over', 'Things to ponder', etc., apart from exercises at the end of each lesson. These contents support equipping students to inculcate 'why' and 'how' in the context of the concepts. Such

learning promotes science literacy. However, these activities are not what students are examined for. Given that, there is a need to encourage and handhold students to engage in these activities. The survey does not support that is happening as of now.

Others

- Though the study is based on a relatively large sample drawn from representative schools, any generalisations for a wider population need further studies of this nature.
- Learning deficits during the COVID years may have affected science literacy performance among the respondent group.
- There is a need for an interest group of teachers to engage continuously on science literacy tests and develop a question bank, which includes items at low, medium and high cognitive levels. Forthcoming efforts in this direction could use these alternative questions to examine overlapping science literacy skills. These efforts cumulatively pave the way to understanding the current science literacy levels and also facilitate the inculcation of these skills across the regions.
- There is also a need to work on study materials that inculcate science literacy skills like hypothesis generation, evidence generation, evidence evaluation, drawing conclusions, communicating, etc., that go beyond the prescribed syllabus.

The general low science literacy scores could be due to learning deficiency during COVID years. There is a need for follow-up studies to ascertain whether the students in the coming years would have successfully coped with the deficiency.

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