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Igniting Minds, Inspiring Change: Elementary Teachers and Science Education

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Abstract: In recent decades, research in scientific education, grounded in the scientific-Technology-Society triad, has attained significant prominence, stemming from the perspective that Science and Technology (S&T) serve as catalysts for societal advancement. Understanding the participation of instructors in the first cycle of basic education is crucial, as they serve as a fundamental pillar for future development, particularly through the inspiration they can instill in their students. This essay aims to analyze first cycle teachers (elementary school teachers for grades 1-4) in the district of Tiruvallur district, Tamil Nadu as social and cultural agents. The findings indicate a cohort of educators exhibiting moderate interest in science and technology matters, alongside a pronounced interest in environmental problems. The significance of this subject indicates that educators have been affected by educational policies and the volume of information obtained from the media regarding this topic. Despite comprising highly experienced educators, the sample exhibited a level of involvement well below expectations, demonstrating interest primarily in participating in environmental discussions and meetings. The authors emphasize that teachers' involvement in science and technology stems from their social and cultural interactions within society. They highlight the necessity of establishing a social network to foster a "identity" capable of navigating a landscape marked by swift scientific and technological advancements, thereby reinforcing the scientific knowledge of the participating educators and enhancing the educational role of these social actors in advancing and cultivating scientific literacy.

Keywords: Science–technology–society (STS), elementary school teachers, scientific literacy, environmental awareness, social and cultural agency

INTRODUCTION

The rapid advancement of science and technology in the twenty-first century requires citizens to stay up to date. People get information in a variety of ways and through a variety of communication channels, and before it can be used to comprehend knowledge, it must be processed and absorbed. The function of science education is precisely in the creation of scientific and technological tools that enable citizens to be contextualized within society. The notion that "all students, regardless of individual and cultural differences, should develop a scientific and technological literacy" reflects the educational goal of the science curriculum (Costa, António, et al).

Understanding fundamental scientific concepts, drawing links between science, technology, and society, cultivating good attitudes and values toward science, and comprehending the nature of science are all components of this effort to promote scientific literacy. Additionally, students should improve their ability to think critically, solve problems, and make decisions. According to studies on the subject, scientific subjects are becoming increasingly scarce in higher education (Maarman, G. J.). Furthermore, there are fewer research conducted during the first few years of teaching, therefore only a broad framework may be suggested (Luft, Julie A., et al.). Studies on the function of instruction in fostering scientific literacy are even more sporadic, which leaves us with a dearth of useful information (Osborne, Jonathan), (Fortus, David, et al.).

Considering the aforementioned, the current study is novel in that it aims to assess the level of scientific literacy of Tiruvallur district first cycle teachers, or elementary school teachers (grades 1-4), by ranking their interest in learning about Science & Technology (S&T) subjects. This research focuses on primary school teachers in an effort to determine how much the position of the teacher in society affects scientific instruction.

Given that cognitive tools can be developed for individuals who contribute to the harmonious development of the relationship between Man and Nature, the first part of this research contextualizes the concept of scientific literacy in retrospect as inherent to the individual who actively participates in society. This, in turn, legitimizes many of the political strategies of the S&T matrix (Li, Yanyan, and Mengmeng Guo). The significance of promoting science and technology will be examined in the article's second section within the elementary school setting, where teachers serve as a bridge between the classroom and society. Lastly, the findings will be discussed in order to offer potential courses of action for the defining of the optimization of scientific literacy levels for primary school instructors.

Scientific literacy

Since the beginning of the 21st century, there has been a lot of conflict between society and science. On one side, quick changes in digital technology, biotechnology, and artificial intelligence are always changing our lives, economies, and cultures, which make us, value new ideas. Conversely, this rapid pace has incited extensive criticism and public discourse over the trajectory and ethics of scientific advancement, as demonstrated in debates concerning climate change, vaccine hesitancy, and data privacy. This modern dynamic is similar to changes that have happened in the past, but the digital environment makes them happen faster and on a larger scale. In the past, public influence was often ignored, but now it is a strong force. Through social media campaigns, citizen science projects, and organized advocacy, the public can quickly come together to support, challenge, or change scientific and technological agendas, holding both corporations and governments accountable.

In this setting, scientific literacy is no longer a luxury; it is a necessary skill for being an active citizen and having control over your own life. The contemporary objective transcends mere comprehension of scientific truths. It entails developing the capacity to traverse a complicated information environment, distinguishing reliable sources from falsehoods, and comprehending the interconnectedness of science with societal values, economics, and politics. Contemporary scholars assert that genuine literacy enables individuals to participate in discussions regarding topics such as gene editing or algorithmic prejudice, where technological expertise immediately crosses with ethical considerations and collective decision-making. For science to be open to everyone, all citizens—not just a small group of experts—need to have the ability to question, analyze, and add to the scientific conversations that determine our shared future.

As a result, the notion of scientific literacy has changed into a multidimensional framework that works for today's problems. It includes knowing what scientific knowledge is and what it isn't, learning important ideas from different fields that help us comprehend the world, and learning how to solve issues and make smart choices. It is also important to understand how science, technology, and society interact with each other and to appreciate the cultural factors that affect both public trust and scientific research. In reality, this means being able to think critically about scientific assertions in the news, work with data, and join in on public discussions. The contemporary interpretation endeavors to reconcile formal scientific knowledge with varied community-based perspectives, conceptualizing literacy not merely as the gathering of data, but as a practical and critical skill vital for success in a technology-driven society.

Nature of the Concept

The term "literacy" has many different meanings and applications; it can be used to refer to learning, competency, or the bare minimum of functional ability to function in society. Thus, comprehending the term literacy's semantic development aids in framing the idea's character.

The term "literacy" comes from the Latin word "literatus," which has changed throughout time from its original meaning of "those who acquire knowledge" to its current meaning of "the set of minimum knowledge and skills required to play a

specific role in society" (Taylor, Natalie Greene, and Paul T. Jaeger). This stage of using scientific knowledge to perform in various social settings points to a social environment in which the definition of scientific literacy emphasizes competence since it aims to complete a task. This job could involve reading a science-related newspaper or journal, applying critical and autonomous thinking skills to an issue, or using logical reasoning or quantitative analysis. This raises the bar for scientific literacy in terms of task-resolution scenarios, which are defined by the extent of social interaction (García-Carmona, Antonio). Because scientifically knowledgeable citizens are encouraged to actively participate in scientific and technological decision-making as well as to keep an eye on their governments' scientific policies, there is a high degree of interaction between science and society. This normative viewpoint holds that in order for citizens to make informed judgments, they should have access to enough information to define their scientific knowledge (Sinatra, Gale M., and Barbara K. Hofer). It turns out that citizens develop alternative concepts without a scientific foundation when they are deprived of this knowledge and scientific content (Wiyarsi, Antuni et al.). The lay public vs. science specialist distinction was the result of the widespread opinion by the early 1990s that skepticism and unbelief toward S&T stem from alternative interpretations of scientific concepts. It stems from the citizen's lack of faith in S&T as opposed to the specialist's "excess" of faith (Gross, 1994).

The "Deficit Model"—which is defined by a high, albeit not particularly strong, link between theoretical scientific knowledge and a positive attitude toward science—was born out of this disconnect between S&T and the public. This assessment of citizens' lack of scientific understanding is incomplete if we do not take into account the social environment of each individual, to the extent that worries that erode the interaction between citizens and science lead to the belief that each person creates their own universe. Therefore, the prevailing societal belief on the dangers of participating in S&T cannot be countered by scientific knowledge alone (Nazemi, Pouria).

A conceptual framework that encourages engagement between citizens and society through a participatory model or exchange of ideas in which the general public and science specialists communicate, benefiting both parties, is necessary to "fight" against this knowledge gap among its citizens. The relationship put out by Chakravartty and Anjan is predicated on the idea that people exchange experiences, viewpoints, and scientific knowledge that advances society's comprehension of S&T (Chakravartty, Anjan.). This is the exact moment when a new style of instruction that rejects the idea of non-contextualized science and is unrelated to social interests and limitations begins to take shape. Following in its footsteps is an educational model that ought to promote "science as culture", anticipating the contextualized scientific knowledge in society, gained and internalized as value, and in the way of their own organizations (Michali and George Eleftherakis).

From science education to the subculture of teachers

The incorporation of this investigative line that supports science as the catalyst for societal growth has given science education research, which is founded on the science-technology-society (STS) line of inquiry, a unique dimension in recent decades. Many conceptual frameworks of the STS Perspective have influenced educational policies on science education as a result of the creation and evolution of the scientific literacy concept, as previously demonstrated, and its repercussions, such as the public understanding of science or scientific culture, or "la culture scientifique" (the latter term also adopted by UNESCO).

In the past, the need to increase innovation in scientific education led to the development of the scientific-Technology-Society idea in the late 1970s and early 1980s. Bijker had previously proposed this idea in Science Education, writing that "understanding the interrelationship between science, technology, and society can be as important for the citizens of the future, in democratic societies, as understanding the concepts and processes of science" (Bijker). New and varied ideas were presented by this epistemological framework, including an evaluation of science's function as a social actor, the urgent need to enhance science education for action, and an approach to multidisciplinary education. After almost thirty years, the STS perspective can be viewed as a temporal spiral that continues to be a popular teaching methodology, subject to new understandings and improvements to its conceptual framework brought about by the necessity of tracking the development of the idea of scientific literacy in all of its forms. Peter Fensham is cited by Aikenhead (2005) as an illustration of this development; in 1985, Fensham contextualized S&T in pertinent subjects for students, creating links between scientific and technological education. At this point, the one-way impact of science and technology on society was a defining feature of Fensham's STS viewpoint. Fensham later rethought the impact of science, technology, and society in the 1990s using the bi-directional interaction mode. Bingle and Gaskell (1994) used this concept when they mentioned the necessity of gaining scientific and technological knowledge in order to establish a foundation for decision-making and problem-solving, which is a fundamental aspect of the Science/Technology/Society trinomial. Interculturality has added a new dimension to the

STS perspective's progress. The founder of this school of thought, Aikenhead (2007), brought attention to the significance of framing science education in the economic, social, and environmental development of societies in addition to the necessity of incorporating a cultural perspective into STS instruction in order to negotiate cultural boundaries worldwide. The ultimate goal of science education is to make science more relatable. Kolsto (2000) elevated this cultural aspect of science to a new level by concentrating his research on the analysis of contentious topics, which is essential for making decisions on contentious scientific-based matters. "This author [Kolsto] considers the argument that improving citizen/student performance needs to emphasize science and production processes of scientific knowledge as an institution," according to Cachapuz (2008). As the STS Perspective notion has developed, several interpretations have surfaced, leading to certain disruptions. In order to reduce the concept's interference, Aikenhead (2007) developed a spectrum of meanings for the STS Perspective based on the degrees to which science and technology interact with social topics. This spectrum expresses the relative importance given to the STS contents while accounting for two factors: student assessment (emphasizing STS content versus traditional science content) and content structure (STS content and traditional science content ratio). Eight categories with differing levels of teacher engagement in STS content developed as a result of these characteristics.

Table 1

1.	Motivation according to STS content.
2.	Casual incorporation of STS content.
3.	Intentional incorporation of STS content.
4.	Specific subject via STS content.
5.	Science via STS content.
6.	Science along with STS content.
7.	STS content

In today's culture, where most people use digital media, the best way to get people interested in science and technology is to use media as a main way to do it. However, modern scholarship stresses that meaningful involvement must transcend the perception of scientific knowledge as a mere commodity for specialists, advocating for its incorporation into society discourse from the beginning. This study aims to examine the intricate interaction between media exposure, personal interest, and active involvement among primary school teachers—a pivotal group in influencing scientific comprehension. Specifically, it investigates three interrelated hypotheses: the correlation between a teacher's interest in science and technology (S&T) topics and their level of media-informed knowledge; the relationship between their engagement with S&T and their interest; and the connection between their engagement and the scientific information they obtain through media channels.

MATERIAL AND METHODS

This study was conducted in the primary schools in the Tiruvallur district, which are part of the first cycle of basic education (1st CBSC) and cover grades 1-4. Using the cluster sampling methodology and the probabilistic sampling method, the sample is based on the teachers at these schools.
Of the 85 individuals in the study, 77 (90.6%) were female (Mo = 1) and 8 (9.4%) were male. The sample ranged in age from 30 to 61, with an average age of 48.36 years (SD = 6.44). Two (2.4%) have a master's degree, 80 (94.1%) have a degree or its equivalent, and three (3.5%) did not respond (Mdn = 1, IQQ = 0). The average tenure of these educators is 24.28 years (SD = 7.13), with a minimum of four years and a maximum of thirty-one years of experience. The first studies to measure scientific literacy appeared in the late 1950s and subsequently in the 1970s due to the necessity to gauge citizens' level of scientific understanding. The National Science Foundation conducted these initial investigations in the United States of America. Ten years later, the European Commission released its initial research on European people' scientific literacy. The findings of this survey have been reported since its initial publication in a number of editions, including the most recent one, the "level of knowledge – Special Eurobarometer/Wave 340 73.1. – TNS Opinion and Social questionnaire". The Eurobarometer is a methodological tool used to assess scientific knowledge and its relationship to science attitudes and interests, which is then used to analyze how European citizens see science and technology. Six topics from the most recent version of the "level of knowledge – Special Eurobarometer/Wave 340 73.1. – TNS Opinion and Social questionnaire" were translated into Portuguese and used in this study using a comparable Likert scale. This work was based on an exploratory, non-experimental study that started with a review of the literature to identify the research questions, objectives, sample, and testing tool. The choice of a previously used questionnaire ensured the validity of the instrument. After identifying these factors, the instructors at the 18 schools that were sampled from the 14 counties in the Guarda district were contacted via snail mail and then by phone. Following this first communication, a researcher visited each institution to distribute and then retrieve the completed surveys. Without the researcher present, participants answered the surveys on their own. The results are shown in the next section after the data was coded and statistically processed using IBM SPSS Statistics Standard.

RESULTS AND DISCUSSION

Degree of Interest in S&T topics

Table 1 shows that 78.8% of the sample are "Very Interested" in environmental issues, whereas just 21.2% are "Moderately Interested" (with the median and mode at 1). Notably, 43.5% of respondents said they were “Very Interested” in the topic of New Medical Discoveries, while the majority (56.5%) said they were “Moderately Interested” (matching to the median and the mode at 2 – “Moderately Interested”). Conversely, on the topic Sports News, 35.8% of respondents said they were "Not Interested," despite the fact that the majority of responses were "Moderately Interested" (with the median and mode at 2). This outcome might derive from the fact that many of the teachers were women, who are less likely to follow sports news.

Table 1

Interest Level	Environmental Problems	New Medical Discoveries	New S&T Discoveries	Sports News	Art & Culture	Politics
Very Interested	78.8%	43.5%	37.8%	4.7%	25.9%	8.2%
Moderately Interested	21.2%	56.5%	58.8%	54.1%	69.4%	64.7%
Not Interested	–	–	2.4%	35.8%	3.5%	22.4%
Don’t Know	–	–	1.0%	5.4%	1.2%	4.7%

Degree of Information acquired through the Media

According to Table 2, Environmental Issues has the highest degree of knowledge obtained through the media (28.2%), followed by Sports News (19%) and Politics (18.8%). However, nearly every response for the topic of environmental issues was classified as either "Very Informed" or "Moderately Informed" (the median and mode are both at 2 – "Moderately Informed"). Additionally, the issue of sports news yields a dissonant response, with 26.4% of respondents saying they "Don't Know."

The similar responses for various subjects can be explained by the fact that these teachers have responded in a "socially acceptable way, wherein teachers tend to respond "comfortably," in accordance with the norms of society, possibly in an unconscious attempt to conceal their own knowledge gaps.

Table 2

Information Level	Environmental Problems	New Medical Discoveries	New S&T Discoveries	Sports News	Art & Culture	Politics
Very Informed (1)	28.2%	2.4%	4.8%	19.0%	8.2%	18.8%
Moderately Informed (2)	70.6%	92.9%	90.5%	53.6%	82.4%	69.4%
Not Informed (3)	1.2%	3.5%	4.7%	–	9.4%	8.2%
Don’t Know (4)	–	1.2%	–	26.4%	–	3.6%

Degree of Engagement in S&T discussions and meetings

With 4.7% of teachers saying they regularly contribute to research, the degree of teacher engagement with S&T is higher when it comes to donations, according to Table 3 statistics. With the median and mode at 4—"Never," which translates to "Never Donates"—the statistical results are subpar. Given the current economic climate, which makes it difficult to donate at all, and the lack of a cultural setting in which to donate to scientific subjects, the results of the donation survey were rather unexpected. These findings may be explained by the way the question was phrased in the context of medicine, which is related to health. Regarding the other items, while the corresponding mode is 3, "Rarely," the median (2, "Occasionally") indicates a higher level of engagement for signing petitions or attending meetings. These findings point to a lower level of S&T teacher engagement, with only sporadic participation in donations and S&T-related conversations and meetings. This fact is of particular importance for the social actor who has a mission to promote/foster this same engagement in S&T students. With this marginal participation in S&T, the production of S&T transmission mechanisms among students will be severely conditioned.

Table 3

Participation Frequency	Donations to medical research	Petitions / demonstrations (nuclear power, biotech, environment)	Meetings or debates on S&T	Member of NGO dealing with S&T
Regularly	4.7%	2.4%	1.2%	–
Occasionally	23.5%	20.0%	24.7%	1.2%
Rarely	21.2%	32.9%	49.4%	15.3%
Never	50.6%	44.7%	24.7%	83.5%

Degree of Interest in S&T topics versus Degree of Information acquired through the Media

Certain the significance of using the media to promote and disseminate scientific knowledge, it is imperative to determine whether there is a relationship between interest in a certain S&T topic and the knowledge acquired about it from the media. This concept is based on the following research question and supporting hypotheses, which are shown in table 4:

Table 4

Research Question 1	Research Hypothesis
Is there a correlation between elementary school teachers' interest in S&T issues and the amount of information they get about them from the media?	The amount of knowledge that primary school teachers learn about S&T concerns via the media is correlated with their level of interest in these matters

The Spearman's Correlation Coefficient was computed for each of the S&T themes (Environmental Problems, New Medical Discoveries, and New S&T Discoveries). Two criteria were used to choose this test: i) the research topic suggests an association test; and ii) the degree of interest and the degree of information are ordinal variables (Martins, 2011). For every issue, the following were the outcomes of using Spearman's Correlation Coefficient:

Table 5

Theme	Correlation Coefficient	Sig. N (2 extremities)	N
Environmental Problems	0.48	0.046	85
New Medical Discoveries	0.23	0.25	85
New S&T Discoveries	0.28	0.061	85

There is a significant positive correlation between elementary school teachers' level of interest and the amount of information they have learned about environmental problems through the media, according to the results of Spearman's correlation coefficient (table 5) and the Statistical Decision (table 6), with rpb = 0.228 and p = 0.036. On the other hand, there is no relationship between elementary school teachers' level of interest and the amount of information they have learned about New Medical Discoveries through the media (rpb = 0.163 and p = 0.135). Nonetheless, New S & T Discoveries revealed a slightly significant positive association between elementary school teachers' level of interest and the amount of knowledge they learned from the media.

Degree of Engagement in S&T discussions and meetings vs. Degree of Interest in S&T topics

The aforementioned findings indicate that elementary school teachers' involvement in S&T is essentially nonexistent, with the exception of attending meetings and participating in S&T-related conversations. In light of these findings, table 7 focuses on Research Question 2 and the underlying research hypotheses regarding participation in S&T meetings and discussions.

Table 6

Research Question 2	Research Hypothesis
Is the degree of engagement of elementary school teachers in S&T discussions and meetings related to the degree of interest in S&T topics?	The degree of engagement of elementary school teachers in S&T discussions and meetings is related to the degree of interest in S&T topics.

Table 7

Theme	Correlation Coefficient	Sig. N (2 extremities)	N
Environmental Problems	-0.003	0.982	85
New Medical Discoveries	0.245	0.024	85
New S&T Discoveries	0.175	0.109	85

There is a significant positive correlation between elementary school teachers' participation in S&T discussions and meetings and their interest in New Medical Discoveries (rpb = 0.245 and p = 0.024), according to the results of the Spearman's correlation coefficient (table 7) and the Statistical Decision (table 6). On the other hand, there is no

relationship between the level of interest in New S&T Discoveries (rpb = 0.175 e p = 0.109) and Environmental Problems (rpb = -0.003 e p = 0.982) and the elementary school teachers' participation in S&T talks and meetings. This final result is noteworthy because the issue of environmental problems performed exceptionally well on the Degree of Interest, suggesting that teachers may be less involved in meetings and discussions when they are highly knowledgeable.
Degree of Engagement in S&T discussions and meetings vs. Degree of Information acquired through the Media

Table 9

Research Question 3	Research Hypothesis
Is the degree of engagement of elementary school teachers in S&T discussions and meetings related to the degree of information on S&T topics acquired through the media?	The degree of engagement of elementary school teachers in S&T discussions and meetings is related to the degree of information on S&T topics acquired through the media.

Table 10

Theme	Correlation Coefficient	Sig. N (2 extremities)	N
Environmental Problems	-0.155	0.157	85
New Medical Discoveries	-0.002	0.987	85
New S&T Discoveries	-0.036	0.793	85

There is no correlation between elementary school teachers' participation in S&T discussions and meetings and the amount of information they learn from the media about environmental problems (rpb = -0.155 and p = 0.157), new medical discoveries (rpb = -0.002 and p = 0.987), and new S&T discoveries (rpb = -0.036 and p = 0.793), according to the results of Spearman's correlation coefficient (table 10) and the statistical decision (table 6). These findings unequivocally demonstrate that there is no correlation between the instructors' participation in meetings and discussions and the knowledge they have learned from the media. We can also deduce that since they are so different, the instructor must take more activity in order to engage students than just impart knowledge. In a similar vein, they may point in opposing directions, resulting in negative correlations: the teacher's participation in S&T meetings and debates will decrease as their level of knowledge increases.

CONCLUSION

The elementary school teacher as a social and cultural actor has been the subject of this study. The findings show that this set of educators has a moderate interest in S&T subjects and a significant amount of interest in environmental issues. This interest's popularity is not surprising, given that environmental subtopics like recycling, ecosystem protection, and global warming and greenhouse gases have received a lot of attention in educational policies in recent years. The degree of interest in environmental issues and the amount of information learned about the same topic from the media are significantly positively correlated, which suggests that teachers' interest is piqued by the topic's frequent appearance in the media. The results for the New Discoveries in S&T topic were lower than the results for the Environmental Problems topic. This indicates that the values may eventually be more in line with those obtained for the Environmental Problems topic if educational agents develop additional educational policies focused on S&T topics (such as lifelong learning, specific plans for the teaching of science, and S&T issues that range across different areas of knowledge) combined with media promotion/dissemination strategies. Despite the fact that the sample is made up of educators with a wealth of teaching expertise, their level of engagement was much below what would be wanted. They appear to be less inclined to participate in S&T meetings and debates the more knowledgeable they are.

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