



Issues and Challenges in Socio-Scientific Approaches in the Teaching-Learning Process

An Analytical Study of Educator Beliefs and SSI Integration in Odisha, India

Gitanjali Mishra

Research Scholar Department of Education, Dr. APJ Abdul Kalam University, Indore (M.P.)

Dr. Preeti Shrivastava

Associate Professor, Department of Education, Dr. APJ Abdul Kalam University, Indore (M.P.)

Abstract

Socio-Scientific Issues (SSI) represent scientifically grounded, socially embedded, and ethically complex real-world problems that serve as powerful vehicles for scientific literacy development. This study analytically examines the issues and challenges educators face when integrating SSI—specifically evolution, climate change, and embryonic stem cell research—into K–12 science curricula. A mixed-method survey was administered to 221 educators (elementary, middle, secondary, and administrators) across Odisha, India. Quantitative data (SPSS 20) included ANOVA, t-tests, chi-square, and linear regression; qualitative data involved line-by-line coding and reasoning quality rubrics. Findings reveal that 73.3% of respondents endorsed SSI integration overall; topic-specific acceptance was highest for climate change (89.4%), followed by stem cell research (69.7%) and evolution (61.6%). Urban educators showed significantly stronger pro-science perspectives than rural educators ($p < 0.001$). Higher science course loads positively correlated with scientific worldview alignment. Significant differences in perspectives emerged by teaching role ($F(6,175) = 8.16, p < 0.001$). Dominant decision-making lenses were educational (75.4%) and scientific (31.6%). Major challenges include inadequate teacher training, ideological conflicts, and structural inequities between urban and rural settings. The study recommends targeted professional development, SSI-oriented curriculum reform, and community engagement strategies.

Keywords: Socio-Scientific Issues (SSI); Science Education; Scientific Literacy; Teacher Beliefs; Climate Change; Evolution; Stem Cell Research; Odisha; India.

1. Introduction

The growing global emphasis on scientific literacy has positioned Socio-Scientific Issues (SSI) as a central feature of contemporary science pedagogy. SSI are real-world problems situated at the confluence of science, ethics, politics, and society—including topics such as climate change, genetic engineering, stem cell research, and evolutionary biology. Unlike traditional science content, SSI demand that students engage in moral reasoning, argumentation, and evidence-based decision-making (Sadler, 2011). The integration of SSI in science classrooms is thus widely recognized as a means of cultivating citizens who can navigate complex, contested scientific challenges in democratic society.

Despite widespread advocacy for SSI-based instruction, its classroom implementation remains inconsistent and contested. Teachers act as the primary gatekeepers of curriculum content, and their personal beliefs, pedagogical training, and content knowledge exert a decisive influence on whether and how SSI are addressed (Berkman, Pacheco, & Plutzer, 2008). In India, this challenge is compounded by structural disparities between urban and rural education, limited teacher preparation for values-based science instruction, and community resistance to controversial topics.

1.1 Background and Context

Roberts (2007) distinguished two visions of scientific literacy: Vision I (content-centric, discipline-focused) and Vision II (contextually enriched, socially embedded). SSI-based instruction is firmly aligned with Vision II, connecting disciplinary knowledge to real-world decisions at personal, community, and global scales (Zeidler, 2014). In Odisha, India, SSI topics intersect with locally pressing concerns—climate vulnerability, biodiversity, agricultural livelihoods, and emerging biomedical research at institutions like AIIMS Bhubaneswar. Understanding how educators in this setting perceive, reason about, and implement SSI is therefore both academically important and practically urgent.

The SSI framework comprises three structural tiers: design components (compelling issues, real-world context, scaffolded higher-order thinking), learner experiences (argumentation, decision-making, ethical reflection), and teacher



1.2 Statement of the Problem

Empirically grounded studies of teacher beliefs and SSI implementation challenges in the Indian educational context are virtually absent from the literature. Existing Western scholarship establishes that ideological factors—religious affiliation, political identity, content knowledge gaps—shape teachers' willingness to engage with SSI (Berkman et al., 2008; Lee & Witz, 2009). This study addresses a critical gap by conducting a comprehensive mixed-method investigation of educator perspectives on SSI integration across elementary, middle, secondary, and administrative roles in Odisha.

The study's primary problem statement is: "AN ANALYTICAL STUDY ON ISSUES AND CHALLENGES IN SOCIO-SCIENTIFIC APPROACHES IN THE TEACHING-LEARNING PROCESS." It posits that personal educator beliefs—rather than curricular mandates—are the primary determinants of SSI inclusion in classrooms.

1.3 Objectives of the Study

1. To study the challenges teachers face related to SSI integration.
2. To assess knowledge of climate change, evolution, and stem cell research among teachers and students.
3. To examine opinion differences across teacher categories and administrators.
4. To study challenges specific to SSI implementation in the classroom.
5. To evaluate SSI as a mechanism for developing scientific literacy.
6. To explore implications of SSI for classroom instructional practice.
7. To investigate challenges teachers face when using SSI in classroom-based teaching.

1.4 Research Hypotheses

H01: There are no significant challenges teachers face related to SSI integration.

H02: There is no significant difference in knowledge of climate change, evolution, and stem cell research between students and teachers.

H03: There is no significant difference in opinions across teacher categories and administrators.

H04: There are no significant challenges for teachers implementing SSI.

H05: There are no significant challenges for teachers when implementing SSI in classroom-based teaching.

2. Literature Review

Research on Socio-Scientific Issues in science education spans cognitive, affective, and civic domains. The following review synthesizes key empirical and theoretical contributions across four thematic areas.

2.1 Theoretical Foundations of SSI-Based Instruction

Zeidler and Nichols (2009) conceptualized SSI-based instruction as an educational paradigm placing morally contentious, socially embedded, and scientifically grounded issues at the center of learning. Sadler's (2011) framework identifies three foundational pillars: design components, learner experiences, and teacher qualities. Zeidler (2014) argued SSI curricula must utilize personally relevant, ill-structured problems requiring scientific evidence-based reasoning; employ scientific topics with social ramifications demanding dialogue and argumentation; integrate implicit or explicit ethical components; and emphasize character development as a long-range pedagogical goal.

Socio-Scientific Reasoning (SSR) was articulated as comprising four dimensions: (1) perceiving SSI complexity, (2) enquiry—recognizing knowledge gaps, (3) perspective-taking across stakeholders, and (4) scepticism toward possibly biased information (Sadler, 2007). These dimensions collectively represent the cognitive flexibility required to navigate contested scientific terrain, and serve as measurable learning outcomes in SSI research.

2.2 Teacher Beliefs and SSI Implementation



Berkman, Pacheco, and Plutzer (2008) demonstrated that one in six high school biology teachers holds a young-earth creationist worldview, directly influencing evolution instruction. Lee and Witz (2009) documented that teachers' epistemic and pedagogical beliefs shaped their willingness to introduce controversial science content, independent of curricular mandates. Sadler and Zeidler (2005) identified three informal reasoning patterns—rationalistic (evidence-based), emotive (welfare-oriented), and intuitive (gut-driven)—that predict argumentation quality in SSI discussions.

Barrett and Nieswandt (2010) found that pre-service teacher candidates held entrenched beliefs about scientific objectivity that conflicted with SSI's value-laden nature, underscoring the need for targeted pedagogical preparation. Research by Nuangchalerm (2009) on pre-service teachers identified three recurring tensions: control of discussion, teacher-student differences in belief systems, and distinctions between science and ethics in classroom discourse.

2.3 Challenges in SSI Classroom Integration

Nielsen and Tidemand (2016) found that biology teachers defaulted to content-centric interpretations of SSI, reducing socio-political complexity to biological fact—expressed through pragmatic pedagogical techniques, content-biased assessment, and reductionist narratives of SSI activity. Ekborg et al. (2020) identified classroom management anxiety, fear of community backlash, and curriculum coverage pressures as primary deterrents. Teachers feared losing control over the science content and worried that valuable classroom time would be spent on non-testable material.

Owens, Sadler, and Zeidler (2017) argued that SSI integration requires restructuring classroom norms from information transmission to collaborative, evidence-based deliberation. In India, additional structural barriers include uneven access to quality science education in rural areas (National Research Council, 2012), limited SSI curriculum resources in regional languages, insufficient teacher training infrastructure, and community resistance to discussing sensitive topics like evolution and stem cell research.

2.4 SSI, Scientific Literacy, and Student Outcomes

Lewis and Leach (2006) demonstrated that students with stronger content knowledge achieved higher argumentation quality in SSI debates, with students in SSI units outperforming peers in scientific content assessments. Zohar and Nemet (2002) showed that even brief SSI interventions significantly improved reasoning quality among secondary students. Gao, Mun, and Kim (2019) evaluated an SSI-based emotional competency curriculum with tenth-graders, finding significant improvements across cognitive, affective, empathic reaction, and emotion regulation dimensions ($\alpha = 0.05$).

Eggert et al. (2013) established that embedded metacognitive instruction within SSI learning environments produced superior outcomes compared to unstructured cooperative approaches, particularly on complex reasoning tasks. Collectively, these findings support SSI's potential to advance scientific literacy—integrating content knowledge, critical thinking, and civic agency—as envisioned by Roberts (2007) Vision II framework.

3. Research Methodology

3.1 Research Design

This study employed a concurrent mixed-method design integrating quantitative survey analysis with qualitative content analysis of open-ended responses. A descriptive survey approach characterized the landscape of educator beliefs about SSI. SPSS 20 was used for all statistical analyses.

3.2 Sample

The target population comprised elementary, middle, and secondary school educators across Odisha, India. A purposive sample of 267 educators was initially recruited. After applying inclusion criteria (minimum responses to background and SSI sections; at least one full set of 10 topic-specific questions answered), 221 participants were retained for final analysis. Educators were drawn from Bhubaneswar, Cuttack, Sambalpur, Baripada, and surrounding rural districts.

3.3 Instruments and Validation

A two-part survey was developed and validated. Part I comprised 16 demographic/background items. Part II contained 30 Likert-scale items (10 per SSI, scored 1–5) and 4 open-ended argumentation prompts. For each SSI, 6 of 10 questions measured topic acceptance; 3 supported the scientific perspective; 3 supported alternative perspectives. Internal consistency was assessed via Cronbach's alpha (Table 3.1). A pilot study ($N = 45$) confirmed face and construct validity.



Table 3.1: Cronbach's Alpha Coefficients – Internal Consistency of Survey Instrument

Study Phase	Scale / Subscale	Cronbach's α
Pilot Study	Overall Score (18 items)	0.739
	Pro-Science Perspective	0.773
Main Study	Overall Score (18 items)	0.771
	Pro-Science Perspective	0.844
	Pro-Alternative Perspective	0.831

3.4 Data Collection and Analysis

Surveys were distributed via SurveyMonkey (URL sent to each participant) and in paper format where internet access was limited. Quantitative analysis used independent-samples t-tests, one-way ANOVA with LSD and Scheffé post-hoc tests, linear regression, and chi-square (SPSS 20). Perspective scores were computed by subtracting pro-alternative scores from pro-science scores per SSI (range: -12 to +12). Educators were grouped by teaching role (7 groups), geographic location (rural/urban), and science course load (Low 0–2, Mid 3–11, High 12+). Qualitative data were analysed via line-by-line coding, constant comparative method, and a reasoning quality rubric (adapted from Wu & Tsai, 2007; Sadler & Donnelly, 2006) scored 0–3 across three dimensions: argument position/rationale, multiple-perspective taking, and rebuttal.

4. Results and Discussion

4.1 Pilot Study: Appropriateness of SSI Topics for Secondary Curriculum

The pilot study (N = 45) assessed whether each SSI topic was appropriate for secondary science classrooms. Climate change received near-unanimous endorsement (93.3%). Evolution was deemed appropriate by 73.3%; those opposed cited community conflict and class time constraints. Stem cell research showed the highest non-response rate (17.8%), indicating sensitivity around its ethical dimensions.

Table 4.1: Pilot Study – Views on Appropriateness of SSI Topics for Secondary Science Curriculum (N = 45)

Topic	Appropriate	Not Appropriate	Undecided	No Response
Evolution	73.3% (33)	22.2% (10)	4.4% (2)	0%
Stem Cell Research	53.3% (24)	28.9% (13)	0%	17.8% (8)
Climate Change	93.3% (42)	2.2% (1)	0%	4.4% (2)

4.2 Overall SSI Acceptance in the Curriculum

Of 182 respondents who answered all 18 SSI questions, the mean overall acceptance score was 63.5 (SD = 8.77) on a scale of 18–90, substantially exceeding the neutral midpoint of 54. As shown in Table 4.2, 73.3% of respondents (n = 162) endorsed SSI integration in formal science education; only 8.1% disagreed.

Table 4.2: General Provision for the Presence of SSI in the Curriculum (N = 221)

Parameter	N	Maximum	Minimum	Mean	S.D.
Overall SSI Score	182	90	34	63.5	8.77

Table 4.3: Distribution of General Provision for SSI Inclusion (N = 221)

Category	Frequency	Percentage (%)
Agree (Include SSI)	162	73.3%
Disagree	18	8.1%
Neutral	2	1.0%
Missing	39	17.6%

4.3 Topic-Specific Acceptance: Favoured Viewpoint Scores



Climate change received the strongest endorsement (89.4%), followed by stem cell research (69.7%) and evolution (61.6%). Perspective scores—computed as the difference between pro-science and pro-alternative scores—were highest for climate change (mean = 2.20, SD = 2.96) and most polarised for evolution (mean = 0.48, SD = 5.62). The stem cell research perspective score was near-neutral (mean = 0.56, SD = 1.95), reflecting ethical uncertainty. Table 4.4 presents the comparative descriptive statistics.

Table 4.4: Topic-Specific SSI Acceptance – Descriptive Statistics and Viewpoint Scores

Parameter	Evolution	Stem Cell Research	Climate Change	Overall SSI
N	203	205	199	182
Mean (Acceptance Score)	20.5	21.0	21.9	63.5
Std. Deviation	4.44	4.36	2.92	8.77
% Agree	61.6%	69.7%	89.4%	73.3%
Perspective Score (Mean)	0.48	0.56	2.20	3.43
Perspective Score (SD)	5.62	1.95	2.96	9.29

4.4 Urban vs. Rural Educator Perspective Scores

Urban educators demonstrated significantly stronger alignment with scientific perspectives across SSI topics. The most pronounced gap was in the overall perspective score: urban educators scored 66.72 compared to 61.0 for rural educators ($t(175) = -4.29$, $p < 0.001$). For evolution, rural teachers showed negative mean perspective scores (-1.02), indicating preference for alternative viewpoints, while urban educators averaged 2.94 in favour of scientific perspectives ($p < 0.001$). Climate change showed no significant rural–urban difference ($p = 0.601$).

Table 4.5: Urban vs. Rural Comparison of SSI Perspective Scores

SSI Topic / Measure	Rural N	Rural Mean	Urban N	Urban Mean	SD	t / p-value
Overall SSI – Overall Score	113	63.9	64	63.0	—	$p = 0.493$ (ns)
Overall SSI – Perspective Score	113	61.0	64	66.72	—	$p < 0.001$ ***
Evolution – Perspective Score	130	-1.02	68	2.94	—	$p < 0.001$ ***
Stem Cell – Perspective Score	132	0.21	70	1.01	—	$p = 0.003$ **
Climate Change – Overall Score	125	21.7	69	22.4	—	$p = 0.123$ (ns)
Climate Change – Perspective	125	2.03	69	2.26	—	$p = 0.601$ (ns)

Note: ** $p < 0.01$; *** $p < 0.001$; ns = not significant

4.5 Effect of Science Course Load on SSI Perspectives

Educators were grouped by number of college-level science courses: Low (0–2; $n=82$, 37.1%), Mid (3–11; $n=59$, 26.7%), and High (12+; $n=80$, 36.2%). Perspective scores increased significantly with higher course loads for overall SSI ($F(2,182) = 11.0$, $p < 0.001$), evolution ($F(2,200) = 9.07$, $p < 0.001$), stem cell research ($F(2,204) = 9.21$, $p < 0.001$), and climate change ($F(2,196) = 4.35$, $p = 0.014$). LSD post-hoc tests confirmed significant differences between the High group and the Low and Mid groups for all SSI topics. Table 4.6 presents the perspective score means by course load category.



SSI Topic	Low (0–2) Mean	Mid (3–11) Mean	High (12+) Mean	F / p-value
Overall SSI	0.23	2.00	7.13	F=11.0, p<.001
Evolution	–1.25	0.00	2.47	F=9.07, p<.001
Stem Cell Research	–0.69	0.42	1.23	F=9.21, p<.001*
Climate Change	1.67	1.79	2.97	F=4.35, p=.014*

Note: *Welch's test applied (Levene's test violated)

4.6 SSI Perspectives by Instructor Role

Significant differences in perspective scores were found across instructor roles ($F(6,175) = 8.16, p < 0.001$). Middle and high school science teachers demonstrated the strongest pro-science perspectives (8.57 and 8.95 respectively). Elementary science teachers recorded the most negative perspective scores (–3.89), indicating preference for alternative viewpoints. Administrators also showed strongly positive science perspectives (7.65). These patterns confirm that subject specialisation and school level are critical variables in SSI disposition.

Table 4.7: SSI General Score and Perspective Score by Instructor Role

Measure	Elem. Non-Sci	Elem. Sci	Mid. Non-Sci	Mid. Sci	High. Non-Sci	High. Sci	Admin
N	29	18	42	23	28	19	23
Mean (General Score)	61.4	57.4	66.3	62.1	66.9	64.6	61.8
SD (General Score)	7.92	7.17	8.96	7.71	8.96	6.90	9.80
Mean (Perspective Score)	–1.00	–3.89	4.07	8.57	0.36	8.95	7.65
SD (Perspective Score)	5.67	7.37	7.11	7.76	8.55	11.0	11.3

$F(6,175) = 8.16, p < 0.001$ (confirmed by Welch's test)

4.7 Evolution – Views by Instructor Role

Significant differences in evolution perspectives emerged across instructor roles ($F(6,196) = 11.4, p < 0.001$). High school science teachers scored highest on pro-evolution perspectives (mean = 4.76), while elementary science teachers were the most negative (mean = –5.15). Pro-evolution mean (8.06–12.6) and pro-alternative mean (7.74–12.3) scores showed clear role-based stratification. Table 4.8 presents these data.

Table 4.8: Evolution – Pro-Science vs. Pro-Alternative Scores by Instructor Role

Measure	Elem. Non-Sci	Elem. Sci	Mid. Non-Sci	Mid. Sci	High. Non-Sci	High. Sci	Admin
N (Perspective)	34	20	49	24	30	21	25
Perspective Score Mean	–2.15	–5.15	0.86	3.63	–0.67	4.76	2.60
Pro-Evolution Mean	8.06	7.10	11.3	12.2	10.4	12.6	11.5
Pro-Alternative Mean	10.2	12.3	10.5	8.54	11.1	7.74	8.93

$F(6,196) = 11.4, p < 0.001$ (Welch's $p = 0.000$ after Levene's violation)

4.8 Stem Cell Research and Climate Change by Instructor Role

For stem cell research, significant differences were found in overall ($F(6,198) = 4.18, p = 0.001$) and perspective scores ($F(6,196) = 6.03, p < 0.001$). High school non-science teachers showed the highest overall SCR acceptance (mean = 22.7). Elementary science teachers had the lowest (mean = 17.3). For climate change, overall scores showed no significant


Table 4.9: Stem Cell Research – Overall and Perspective Scores by Instructor Role

Measure	Elem. Non-Sci	Elem. Sci	Mid. Non-Sci	Mid. Sci	High. Non-Sci	High. Sci	Admin
N	31	21	45	24	35	22	27
Overall Score Mean	20.9	17.3	21.8	20.2	22.7	21.6	20.6
Overall Score SD	4.47	5.34	4.15	4.31	3.24	3.81	4.02
Perspective Score Mean	-0.32	-0.86	0.73	1.04	-0.028	1.55	1.56
Perspective Score SD	1.33	1.77	1.50	1.49	1.76	2.48	2.49

$F(6,198) = 4.18, p = 0.001$ (Overall); $F(6,196) = 6.03, p < 0.001$ (Perspective, Welch's confirmed)

4.9 Educator Beliefs About SSI Science and Evidence

Respondents were asked about their views on the scientific validity of each SSI topic. For evolution, only 46.4% viewed it as a credible scientific field, while 53.7% were split between opposition (28.3%) and neutrality (25.4%). Only 33% found evolution evidence to be accurate and unbiased (Table 4.10). For climate change, 65.1% provisionally supported its underlying science; 7.4% disagreed. For stem cell research, 38.5% supported the use of embryos in therapeutic research (Table 4.11).

Table 4.10: View Evolution as a Credible Field of Science (N = 205)

Response Category	Frequency	Percentage (%)
Strongly Oppose (Compete with)	40	19.5%
Oppose	18	8.8%
Neutral	52	25.4%
Support (Provision)	50	24.4%
Strongly Support	45	22.0%

Table 4.11: Support for Climate Change Science and Stem Cell Research (Selected Items)

Item	Strongly Oppose	Oppose	Neutral	Support	Strongly Support	Total N
Climate change is real (Provision for disciplines)	7 (3.4%)	8 (3.9%)	57 (27.7%)	97 (47.1%)	37 (18.0%)	206
Climate change evidence is accurate & unbiased	13 (6.4%)	41 (20.1%)	77 (37.7%)	50 (24.5%)	23 (11.3%)	204
SCR offers therapeutic promise	10 (4.8%)	16 (7.7%)	57 (27.5%)	85 (41.1%)	39 (17.6%)	207
Support use of embryos in research	26 (12.4%)	34 (16.3%)	68 (30.8%)	53 (25.4%)	28 (13.4%)	209

4.10 Decision-Making: Who Should Make SSI Curriculum Decisions

Respondents were asked to identify the most qualified decision-makers for SSI inclusion. Multiple selections were permitted. Scientists and teachers consistently received the highest selection rates across all three SSI topics. Parents were favoured more for evolution (42.5%) than for climate change (27.9%), reflecting the greater ideological sensitivity of

**Table 4.12: Overview of Preferred Decision-Makers for Each SSI (% of Respondents)**

Decision-Maker	Evolution (%)	Stem Cell Research (%)	Climate Change (%)
Scientists	49.3%	54.8%	59.7%
Teachers	57.0%	56.1%	56.6%
Local Administration	37.1%	38.0%	34.8%
School Board	24.4%	22.2%	17.2%
Parents	42.5%	37.1%	27.9%
State Curriculum	31.2%	32.6%	31.7%
National Curriculum	27.1%	28.1%	26.7%

4.11 Reasoning Quality Across Argument Dimensions

Open-ended responses from 114 educators were coded using three reasoning quality rubrics (0–3 each): argument generation, multiple-perspective taking, and rebuttal. The mean total reasoning quality score was 5.52 (SD = 2.26; range 1–9). Only 24.5% of participants scored 8 or 9 (highest band). Most educators scored 2 on argument generation (56.1%), reflecting arguments without sufficient supporting evidence. Table 4.13 presents frequency distributions across all three reasoning dimensions.

Table 4.13: Reasoning Quality Frequency Distributions – Argument Generation, Multiple Perspectives, and Rebuttal

Score	Argument Generation (n)	Argument Generation (%)	Multi-Perspective (n)	Multi-Perspective (%)	Rebuttal (%)
0	1	0.9%	20	17.5%	21.1%
1	6	5.3%	38	33.3%	19.3%
2	64	56.1%	35	30.7%	27.2%
3	63	37.7%	21	18.4%	32.5%

4.12 Decision-Making Lenses Used by Educators

The analysis of open-ended responses identified four decision-making lenses. The educational lens was used by 75.4% of respondents, making it the dominant framework. The scientific/disciplines lens was used by 31.6%. Social and other lenses were used less frequently. Most educators (58.4%) operated from a single lens; 33.3% used two lenses. Within the educational lens, three sub-perspectives emerged: promote critical thinking (40.7%), personal view of science education (20.9%), and discipline supports traditional content (38.4%). Table 4.14 presents these data.

Table 4.14: Decision-Making Lenses – Frequency and Characteristics

Decision-Making Lens / Category	Frequency	Percentage (%)
Education Lens (Total)	86	75.4%
– Promote Critical Thinking	35	40.7% of Edu.
– Personal View of Science Education	18	20.9% of Edu.
– Discipline Supports Content	33	38.4% of Edu.
Science/Disciplines Lens (Total)	36	31.6%
Social Lens	28	24.6%
Other Lenses	19	16.7%
Used Only 1 Lens	66	58.4%
Used 2 Lenses	38	33.3%
Used 3 Lenses	9	8.0%



5. Conclusion

This study presents a comprehensive analytical account of the issues and challenges confronting educators seeking to integrate Socio-Scientific Issues into science teaching in Odisha, India. Seven key findings emerge from the analysis.

First, the majority of teachers (73.3%) endorse SSI inclusion in principle. This is a strongly positive baseline. However, endorsement varies significantly by topic: climate change commands near-universal acceptance (89.4%), while evolution remains contested (61.6%), reflecting the persistent influence of religious belief systems and community pressures on teacher decision-making—consistent with Berkman et al. (2008) and Moore, Brooks, and Cotner (2011).

Second, a significant urban–rural divide exists in perspective scores, with urban educators scoring 5.7 points higher than rural counterparts on pro-science perspectives ($p < 0.001$). Rural educators, who constitute 65.2% of the sample, are systematically less exposed to contemporary scientific discourse, SSI training, and cosmopolitan knowledge networks. Addressing this gap requires targeted professional development initiatives and regionally relevant curriculum materials.

Third, teaching role is a powerful moderator of SSI perspectives. Middle and high school science teachers demonstrated the strongest pro-science alignment (perspective scores of 8.57 and 8.95 respectively), while elementary science teachers showed the most negative scores (−3.89). This underscores that SSI professional development must be differentiated by role and grade level.

Fourth, science course load positively and significantly predicts scientific worldview alignment across all three SSI topics. The High course load group (12+ courses) consistently outperformed Low and Mid groups in perspective scores—but this relationship is not deterministic. Even educators with strong science backgrounds showed emotive and intuitive reasoning patterns, highlighting the need for explicit argumentation and values-based pedagogy training.

Fifth, reasoning quality among educators is moderate: mean total score of 5.52/9, with only 24.5% in the highest band (8–9). Most educators (56.1%) scored at level 2 in argument generation—constructing arguments without sufficient supporting evidence. This indicates a significant gap between subject knowledge and SSI reasoning capacity that structured training can address.

Sixth, the dominant decision-making lens is educational (75.4%), centering on how SSI material should be taught rather than its scientific merit. This pedagogical orientation supports scaffolded SSI integration. However, the educational lens encompasses divergent sub-perspectives—critical thinking advocates, science content defenders, and alternative-view supporters—indicating that lens orientation alone does not predict SSI outcomes.

Seventh, the preferred decision-makers for SSI content—scientists (49.3–59.7%) and teachers (56.1–57.0%)—reflect appropriate epistemic authority. However, the notable proportion selecting parents (27.9–42.5%) signals that community stakeholder engagement is essential, particularly for ideologically charged topics like evolution.

In conclusion, advancing SSI-based science education in India demands a systemic response: curriculum frameworks embedding SSI across grade levels; differentiated teacher training building comfort with ambiguity; assessment reforms rewarding critical thinking; and community partnerships legitimising the discussion of contested scientific topics. Future longitudinal research should evaluate the impact of SSI-oriented professional development on classroom practice and student outcomes in Indian educational settings.

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