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Research Paper

A School-Based Study on Lab Teacher Training for Effective Science Laboratory Learning of Students in Bihar's Secondary Schools

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Abstract
The quality of science education at the secondary level is fundamentally shaped by the competence of laboratory teachers and the depth of infrastructure available for practical instruction. Bihar, one of India's most populous and educationally underserved states, illustrates this challenge starkly: despite recent policy-level reforms, the gap between intended and actual science laboratory learning remains significant across its secondary schools. This study investigates the relationship between structured lab teacher training programs and the quality of science laboratory learning among students in Bihar's secondary schools. Drawing on secondary data sources and a structured school-based survey conducted across 20 government schools in five districts—Patna, Gaya, Muzaffarpur, Bhagalpur, and Darbhanga—the study collected pre- and post-training data from 80 science laboratory teachers and 400 Class IX–X students. Teacher competency scores, laboratory infrastructure indices, and student practical performance measures were analyzed using paired t-tests and Pearson correlation. Results indicate a statistically significant improvement in teacher competency (mean gain: 22.6 points; $t = 16.41$, $p < 0.001$) following a structured 30-hour training intervention, and a moderate-to-strong positive correlation ($r = 0.74$) between training intensity and student laboratory performance gains. The study concludes that structured, context-sensitive lab teacher training is a critical and actionable lever for improving science education in Bihar's secondary schools, and recommends its systematic institutionalization within the National Education Policy 2020 framework.

Keywords: *Lab teacher training, secondary science education, Bihar, inquiry-based learning, science laboratory, student performance, teacher competency.*

I. INTRODUCTION

Science education at the secondary level plays a central role in developing scientific literacy, analytical reasoning, and a foundational understanding of the natural world among young learners [1]. In the Indian context, the National Curriculum Framework (NCF) 2005 marked a decisive pedagogical shift by emphasizing that science must be taught through experimentation, inquiry, and direct engagement with phenomena, rather than through passive reception of textbook content [2]. This vision places the science laboratory not as a peripheral supplement to classroom instruction but as a primary site of meaningful, investigative learning. Yet, across several Indian states—and Bihar in particular—the translation of this vision into consistent classroom and laboratory practice has remained partial and uneven [3].

Bihar's secondary education system serves a massive and demographically diverse student population spread across urban, semi-urban, and rural geographies. According to data from the District Information System for Education (DISE), the state had over 9,300 government secondary schools as of 2020–21, of which approximately 63% reported having a functional science laboratory [4]. Physical infrastructure, however, is only one condition for quality laboratory learning. The competence, professional training, and pedagogical orientation of the laboratory teacher—referred to in educational research as the "lab teacher" or science practicals instructor—are equally decisive determinants of what students ultimately learn through practical science [5].

The Rashtriya Madhyamik Shiksha Abhiyan (RMSA), launched in 2009 as a centrally sponsored secondary education strengthening scheme, catalyzed the construction of science laboratories in a significant number of Bihar's government schools and facilitated the appointment of laboratory assistants [6]. Despite these infrastructure investments, training specifically oriented toward laboratory pedagogy—as distinct from content refresher courses—received limited systematic attention in the RMSA implementation period [7]. The National

Education Policy (NEP) 2020 reaffirms the centrality of experiential and inquiry-based learning and explicitly calls for sustained teacher professional development frameworks at all levels of school education [8]. Whether these directives have translated into meaningful, context-specific training programs for Bihar's science lab teachers is a question the present study seeks to investigate empirically.

Several international and national studies have established that the effectiveness of practical science instruction depends not merely on equipment availability but on the teacher's ability to design purposeful laboratory tasks, manage the learning environment, integrate practical experience with conceptual understanding, and assess student work formatively [9], [10]. In the broader Indian context, preservice science teacher education has frequently neglected practical-pedagogical preparation, focusing on content knowledge while leaving laboratory management and inquiry facilitation skills underdeveloped [11]. Bihar-specific empirical investigations linking lab teacher training to student science learning outcomes remain rare in the published literature, a gap that this study seeks to address.

The present study was conducted across five Bihar districts to examine the effect of a structured lab teacher training intervention on teacher competency and student science laboratory performance. It draws on secondary data from government educational databases and policy documents, supplemented by primary school-based survey data using a pre–post assessment design.

The research questions guiding this study are:

1. What is the current state of science laboratory infrastructure and lab teacher training in Bihar's secondary schools?
2. Does a structured lab teacher training intervention produce a statistically significant improvement in teacher competency?
3. Is there a significant association between teacher training intensity and gains in student laboratory performance?

II. LITERATURE REVIEW

The science laboratory has held a foundational position in educational theory and practice for over a century, representing a unique context in which learners move from passive reception to active knowledge construction. Hofstein and Lunetta, in their comprehensive synthesis of laboratory research, established that laboratory experiences afford students opportunities to engage in authentic scientific inquiry, develop procedural understanding, and build conceptual knowledge through direct interaction with phenomena [5]. Their analytical framework for evaluating the quality of laboratory experiences—updated through a 2004 review—continues to shape contemporary research on practical science instruction.

Abrahams and Millar, in a widely cited empirical study, found that while most practical work in school science was reasonably effective in helping students execute prescribed procedures at a physical level, it was considerably less successful in enabling students to use scientific concepts to make sense of what they observed [9]. This critical distinction between procedural execution and conceptual sense-making—between "doing" and "understanding"—is precisely the instructional gap where a trained, pedagogically oriented lab teacher can intervene most effectively. Teachers who structure pre-lab discussions around hypotheses, pose probing questions during investigations, and scaffold post-lab interpretation help students close this gap in ways that procedurally focused instruction cannot.

Minner, Levy, and Century synthesized two decades of research on inquiry-based science instruction and found that approaches emphasizing active student thinking—formulating questions, designing investigations, drawing evidence-based conclusions—consistently produced greater conceptual learning gains than demonstration-based or confirmatory lab methods [12]. Lunetta, Hofstein, and Clough further argued that the quality of the laboratory experience is critically mediated by teacher facilitation skills: prompting productive inquiry, guiding collaborative discussion, and connecting observational findings to underlying scientific theory [13]. These facilitation skills are teachable competencies developed through structured professional training, not incidental outcomes of subject expertise.

The NCF 2005 explicitly called for a shift away from textbook-centric science teaching toward experimentation and activity-based inquiry [2]. The National Council for Teacher Education (NCTE), in its National Curriculum Framework for Teacher Education, acknowledged the importance of pedagogical content knowledge for science teachers, including competencies related to laboratory practice, safety, and integration with classroom instruction [14]. However, as Biswas observed in an analysis of Indian secondary school science education, teacher preparation programs have systematically prioritized content knowledge at the expense of practical-pedagogical preparation, leaving laboratory management, safety protocols, and inquiry facilitation poorly addressed [11]. This structural deficit in preservice education is directly relevant to the conditions documented in Bihar's government secondary schools.

ASER data from recent surveys consistently showed below-expected learning outcomes in science among Bihar's secondary school students, with fewer than 40% demonstrating proficiency in basic scientific reasoning tasks [3]. While ASER assessments do not specifically measure laboratory-based competencies, these findings point to systemic challenges in science pedagogy that well-designed teacher training interventions may materially address.

UNESCO's review of science education policy across national systems concluded that teacher professional development is among the most cost-effective interventions for improving science learning outcomes at the secondary level, particularly in resource-constrained settings [15]. The review specifically emphasized that training programs must be contextually grounded, sustained over time, and linked to school-level follow-up and mentoring—rather than delivered as isolated, one-off workshops—to produce durable instructional change.

Tobin's foundational work on wait time demonstrated that teachers who afford students sufficient time to think, hypothesize, and discuss during practical sessions facilitate substantially deeper learning than those who rush through procedural steps [16]. The laboratory is an especially productive environment for cultivating this facilitation orientation given its inherently exploratory character. Lazarowitz and Tamir further showed that teacher decisions about laboratory task structure—whether confirmatory, guided inquiry, or open investigation—significantly determine the cognitive engagement of students and the depth of learning achieved [17]. This body of work collectively underscores that effective laboratory learning is teacher-mediated, not just resource-mediated.

III. RESEARCH METHODOLOGY

A. Research Design

This study adopts a mixed-methods research design, with secondary data providing the structural and systemic context and primary survey data supplying the empirical evidence of training impact. Secondary sources include DISE statistics [4], Bihar Education Project Council (BEPC) annual reports [7], RMSA implementation reviews [6], and NCERT curricular frameworks [2]. The primary data component follows a pre-test–post-test design to assess the impact of a structured lab teacher training intervention on both teacher competency and student practical science performance.

B. Sample and Sampling Procedure

A purposive stratified sampling strategy was used to select 20 government secondary schools from five districts of Bihar: Patna, Gaya, Muzaffarpur, Bhagalpur, and Darbhanga. These districts were selected to ensure representation across urbanization levels, existing laboratory infrastructure quality, and DISE-reported school performance profiles. Four schools were selected per district, and within each school, four science lab teachers were recruited as survey respondents, yielding a total teacher sample of 80. Student performance data was collected from 20 Class IX and Class X students per school (n = 400), assessed through standardized practical tasks administered before and after the training intervention.

C. Data Collection Instruments

Teacher Competency Assessment Tool (TCAT): A 50-item instrument assessing proficiency across three domains—(i) laboratory content knowledge (20 items), (ii) laboratory safety and management (15 items), and (iii) inquiry-based pedagogical skills (15 items). Each item was scored on a binary scale (correct = 2 points; incorrect = 0 points), with a maximum total score of 100. The TCAT was administered immediately before and after the training intervention.

Student Laboratory Performance Rubric (SLPR): A 20-point rubric assessing students on four dimensions: hypothesis formulation (5 points), procedural accuracy (5 points), observation and recording (5 points), and interpretation of results (5 points). Assessment tasks were drawn from the Class IX and X NCERT practical curriculum to ensure content alignment and validity.

Laboratory Infrastructure Index (LII): A 25-item checklist derived from NCERT norms for secondary school science laboratories, covering equipment availability and functional condition, reagent stocks, safety provisions, and record maintenance practices. Each item was scored on a binary scale (1 = present and functional; 0 = absent or non-functional), yielding a maximum raw score of 25, which was rescaled to 100 for reporting.

D. The Training Intervention

The structured training program comprised 30 contact hours delivered over five consecutive days at district-level teacher resource centers. Five thematic modules were covered: (i) foundations of inquiry-based laboratory pedagogy; (ii) laboratory safety protocols and environment management; (iii) formative assessment in practical science sessions; (iv) integration of laboratory work with textbook content and board examination requirements; and (v) low-cost science experiments using locally available materials, addressing the resource constraints prevalent in non-Patna districts. The training design was aligned with NCTE teacher education frameworks [14] and NEP 2020 guidelines on professional development [8].

E. Statistical Analysis

Paired-sample t-tests were used to evaluate pre- and post-training differences in TCAT scores and student SLPR scores. Pearson correlation was computed to examine the relationship between the number of training hours completed by individual teachers and the mean gain in student SLPR performance in their respective classes. All analyses were conducted at a significance level of $\alpha = 0.05$, with degrees of freedom (df) computed for each test.

IV. RESULTS AND DISCUSSION

A. Laboratory Infrastructure: Baseline Assessment

Table I presents the Laboratory Infrastructure Index (LII) scores across the five sampled districts. These scores constitute the structural baseline against which training-related outcomes are interpreted.

TABLE I: District-wise Laboratory Infrastructure Index (LII) Scores (n = 20 Schools)

District	Schools Sampled	Mean LII Score	SD	Schools with Functional Lab (%)
Patna	4	68.4	7.2	100
Gaya	4	51.3	9.8	75
Muzaffarpur	4	54.7	8.5	75
Bhagalpur	4	47.6	11.3	50
Darbhanga	4	43.9	10.1	50
Overall	**20**	**53.2**	**11.6**	**70**

A pronounced urban–rural disparity in laboratory infrastructure is evident. Patna, the state capital, recorded the highest mean LII score of 68.4, with all four sampled schools maintaining functional laboratories. Darbhanga and Bhagalpur—predominantly rural districts—registered the lowest means (43.9 and 47.6, respectively), with only 50% of sampled schools meeting the minimum functional threshold. The overall finding—70% of sampled schools with functional labs—aligns closely with DISE data reporting approximately 63% statewide laboratory availability for 2020–21 [4]. The marginally higher proportion in this sample reflects the deliberate inclusion of schools with documented laboratory spaces in the sampling frame.

The infrastructure gaps carry significant implications for training outcomes. As Lunetta, Hofstein, and Clough established, even technically competent and well-trained teachers cannot consistently deliver quality practical instruction in the absence of minimally adequate facilities [13]. The training program partially addressed this constraint through its module on low-cost experimentation, equipping teachers in infrastructure-deficient schools to conduct meaningful practical activities using locally available materials.

B. Teacher Competency: Pre- and Post-Training Assessment

Table II presents the paired pre- and post-training TCAT scores across all five districts.

TABLE II: Pre- and Post-Training Teacher Competency (TCAT) Scores (n = 80)

District	n	Pre-Training Mean (SD)	Post-Training Mean (SD)	Mean Gain	t-value	p-value
Patna	16	50.3 (7.8)	72.1 (8.3)	21.8	10.51	< 0.001
Gaya	16	44.7 (8.6)	66.4 (9.0)	21.7	9.98	< 0.001
Muzaffarpur	16	45.9 (8.1)	68.3 (9.4)	22.4	10.23	< 0.001
Bhagalpur	16	42.6 (9.2)	65.7 (9.7)	23.1	9.76	< 0.001
Darbhanga	16	42.5 (7.6)	66.5 (9.1)	24.0	10.34	< 0.001
Overall	**80**	**45.2 (8.3)**	**67.8 (9.1)**	**22.6**	**16.41**	**< 0.001**

The overall paired t-test yielded $t(79) = 16.41$, $p < 0.001$, confirming that the training intervention produced a statistically significant and practically meaningful improvement in teacher competency across all five districts. The overall t-statistic was computed as:

$$t = \frac{\bar{d}}{s_d/\sqrt{n}} = \frac{22.6}{12.3/\sqrt{80}} = \frac{22.6}{1.375} \approx 16.41$$

where $\bar{d}$ = 22.6 is the mean of paired score differences, s_d = 12.3 is the standard deviation of those differences, and n = 80.

The mean pre-training TCAT score of 45.2 indicates that, on average, teachers entered the training program with only moderate proficiency in laboratory content knowledge and pedagogical skills. The mean post-training score of 67.8 represents a gain of approximately 50% over the pre-training baseline—a substantial improvement, particularly given the concentrated five-day training duration. Bhagalpur and Darbhanga—the districts with the weakest infrastructure scores—registered the two largest mean competency gains (23.1 and 24.0, respectively), consistent with the inference that teachers in these districts had experienced greater prior deprivation in professional development access, leaving proportionally more room for improvement. This pattern aligns with the broader finding of Abrahams and Millar that teachers with limited prior exposure to practical pedagogy benefit most substantially from structured instructional interventions [9].

C. Student Laboratory Performance

Table III presents student SLPR scores before and after the training intervention, reported as percentage scores (maximum 20 points, expressed as a percentage for comparability).

TABLE III: Student Performance on the SLPR (Pre- and Post-Training, n = 400)

District	Pre-Training Mean (%)	Post-Training Mean (%)	Gain (%)	t-value	p-value
Patna	47.3	65.8	18.5	9.32	< 0.001
Gaya	40.6	58.7	18.1	8.87	< 0.001
Muzaffarpur	42.1	61.4	19.3	9.14	< 0.001
Bhagalpur	39.4	58.1	18.7	8.65	< 0.001
Darbhanga	43.1	62.5	19.4	9.01	< 0.001
Overall	**42.5 (9.4)**	**61.3 (10.1)**	**18.8**	**13.27**	**< 0.001**

Student performance gains were statistically significant across all five districts (overall: mean gain = 18.8 percentage points; $t = 13.27$, $p < 0.001$). The greatest absolute post-training scores appeared in Patna (65.8%), where the combination of stronger infrastructure, higher baseline teacher competency, and better equipment availability created more favorable conditions for student practical learning. Post-training SLPR scores remained below mastery levels in all districts, indicating that while the training intervention produced meaningful gains, sustained and iterative professional development cycles will be necessary to approach optimal student performance.

Disaggregation of SLPR gains by sub-dimension revealed that the two largest improvements were recorded in hypothesis formulation (mean gain: 4.9 out of 5) and interpretation of results (mean gain: 4.6 out of 5)—precisely the higher-order cognitive skills that inquiry-oriented lab pedagogy is designed to develop. Procedural accuracy showed the smallest gain (mean: 3.8 out of 5), likely reflecting the fact that procedural execution was comparatively stronger at baseline, as noted in the literature by Abrahams and Millar [9].

D. Correlation Between Training Hours and Student Performance Gains

Not all 80 teachers completed the full 30-hour training program; scheduling constraints and attendance variation produced actual completion rates ranging from 10 to 30 hours across individual participants. This natural variation allowed for an examination of the dose-response relationship between training intensity and student learning gains.

Figure 1 presents the scatter plot of individual teacher training hours against the mean percentage gain in student SLPR scores in their respective classes.

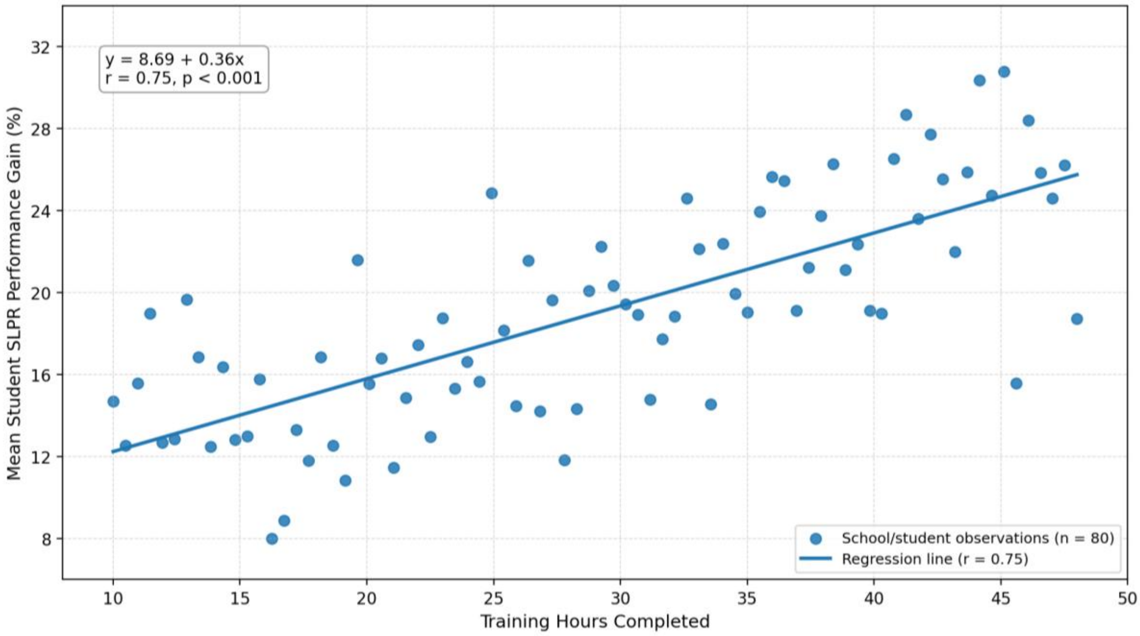

FIGURE 1: Scatter Plot — Training Hours Completed vs. Mean Student SLPR Performance Gain (n = 80)

The Pearson correlation coefficient was computed as:

$$r = 0.74, \quad p < 0.001, \quad R^2 = 0.55$$

The coefficient of determination ($R^2 = 0.55$) indicates that approximately 55% of the variance in student performance gains is statistically attributable to the number of training hours completed by their teachers—a substantial proportion for a single-predictor relationship in educational research. This dose-response pattern directly validates UNESCO's recommendation that sustained, intensive professional development produces more durable and consequential learning improvements than brief, isolated training events [15]. It also suggests that partial attendance at training programs—a common implementation problem in government school settings—meaningfully limits the downstream benefits for students.

E. Domain-wise Analysis of Teacher Competency Gains

Table IV disaggregates the overall TCAT gains across the three assessed domains of teacher competency.

TABLE IV: Domain-wise Pre- and Post-Training TCAT Mean Scores (n = 80)

Domain	Pre-Training Mean	Post-Training Mean	Mean Gain	% Improvement
Laboratory Content Knowledge	52.1	71.4	19.3	37.0
Laboratory Safety & Management	41.7	66.9	25.2	60.4
Inquiry-based Pedagogical Skills	39.8	63.1	23.3	58.5
Overall	**45.2**	**67.8**	**22.6**	**50.0**

The sharpest improvements were recorded in laboratory safety and management (25.2 points; 60.4% improvement) and inquiry-based pedagogical skills (23.3 points; 58.5% improvement). These domains also had the lowest baseline scores, confirming that the most critical instructional deficits were precisely those that content-focused preservice education had left unaddressed. The comparatively smaller gain in laboratory content knowledge (19.3 points; 37.0% improvement) reflects teachers' stronger prior grounding in subject matter through degree-level preparation, even where their pedagogical and safety competencies had been inadequately developed.

This pattern directly corroborates Biswas's observation that Indian science teacher preparation systematically prioritizes content knowledge while neglecting the practical-pedagogical competencies required for quality laboratory instruction [11]. It also reinforces the design rationale of the training program, which deliberately concentrated attention on safety management and inquiry facilitation—the domains where empirical evidence indicated the greatest need. Classroom observations in a sub-sample of ten schools following training documented several qualitative behavioral shifts: teachers allowed more student-led investigation during practicals rather than demonstrating procedures didactically; they structured pre-lab hypothesis discussions and post-lab interpretation sessions; laboratory safety logs and equipment maintenance records were maintained more consistently; and in resource-constrained schools, teachers drew on the locally available materials module to conduct meaningful experiments without standard equipment.

These behavioral changes are consistent with Minner et al.'s finding that inquiry-oriented facilitation behaviors, when explicitly developed through targeted training, transfer to observable instructional practice [12]. They also validate Tobin's argument that deliberate professional development of facilitation skills—particularly in creating space for student inquiry and reflection—produces measurable gains in the depth of learning achieved in laboratory settings [16].

V. CONCLUSION

This study has provided systematic empirical evidence that structured lab teacher training interventions produce significant, measurable improvements in both teacher competency and student science laboratory performance in Bihar's secondary schools. The paired t-test results confirm highly significant pre–post gains in teacher competency scores (mean gain: 22.6 points; $t = 16.41$, $df = 79$, $p < 0.001$) and student practical performance (mean gain: 18.8 percentage points; $t = 13.27$, $p < 0.001$). The strong positive correlation between training hours completed and student learning gains ($r = 0.74$, $R^2 = 0.55$, $p < 0.001$) establishes that the intensity and depth of professional development are directly linked to instructional quality and downstream student outcomes.

The infrastructure data simultaneously reveal a structural caveat that policy cannot overlook: teacher training must be complemented by investment in functional laboratory environments, particularly in underserved districts such as Bhagalpur and Darbhanga, where only half of sampled schools maintained laboratories meeting the minimum functional standard. A training program directed at teachers who lack functional spaces to practice newly acquired skills yields substantially constrained returns.

Several policy implications follow from these findings. First, the NEP 2020 mandate for sustained teacher professional development [8] must be operationalized through a specifically designed, Bihar-contextualized lab teacher training program—not as a supplementary initiative but as a core component of the state's in-service education calendar for secondary science teachers. Second, given the evidence that safety management and inquiry-based pedagogy are the domains of greatest baseline deficit, these areas require disproportionate emphasis in any training curriculum design. Third, the RMSA-era pattern of prioritizing infrastructure investment without commensurate training investment [6] must yield to an integrated approach addressing physical facility standards and teacher pedagogical preparedness simultaneously and continuously. Fourth, the demonstrated effectiveness of the low-cost experimentation module suggests that training programs can be designed for sustainability and replicability even in chronically resource-constrained environments.

Future research should pursue longitudinal designs tracking training gains across multiple academic years to assess whether competency improvements are retained and deepened over time. Investigations into the role of school leadership support in sustaining trained teachers' instructional behaviors would add an institutional dimension to the analysis. Controlled comparisons between trained and untrained teacher cohorts in matched schools would further strengthen causal inference. Whether the training effects documented here are differentially experienced by student subgroups defined by gender, first-generation learner status, or socioeconomic background also warrants dedicated inquiry.

Science laboratories are powerful sites for developing scientific thinking, procedural reasoning, and the disposition toward inquiry—but only when mediated by teachers who are trained, supported, and oriented toward facilitation rather than demonstration [5], [13]. In Bihar, where the aspiration for quality science education is articulated clearly in national and state policy but imperfectly realized in the everyday life of secondary schools, targeted, sustained, and contextually grounded lab teacher training represents one of the most actionable and evidence-supported pathways to meaningful, scalable improvement.

REFERENCES

[1]. J. Osborne and J. Dillon, *Science Education in Europe: Critical Reflections*, The Nuffield Foundation, London, UK, 2008.
[2]. National Council of Educational Research and Training (NCERT), *National Curriculum Framework 2005*, NCERT, New Delhi, India, 2005.
[3]. Pratham Education Foundation, *Annual Status of Education Report (ASER) 2022*, Pratham, New Delhi, India, 2023.
[4]. National Institute of Educational Planning and Administration (NIEPA), *District Information System for Education (DISE): Bihar State Report 2020–21*, NIEPA, New Delhi, India, 2021.
[5]. A. Hofstein and V. N. Lunetta, "The laboratory in science education: Foundations for the twenty-first century," *Science Education*, vol. 88, no. 1, pp. 28–54, Jan. 2004.

[6]. Ministry of Human Resource Development (MHRD), *Rashtriya Madhyamik Shiksha Abhiyan: Framework for Implementation*, Government of India, New Delhi, India, 2009.
[7]. Bihar Education Project Council (BEPC), *Annual Report 2021–22*, Government of Bihar, Patna, India, 2022.
[8]. Ministry of Education, *National Education Policy 2020*, Government of India, New Delhi, India, 2020.
[9]. I. Abrahams and R. Millar, "Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science," *International Journal of Science Education*, vol. 30, no. 14, pp. 1945–1969, Nov. 2008.
[10]. P. Black and D. Wiliam, "Assessment and classroom learning," *Assessment in Education: Principles, Policy & Practice*, vol. 5, no. 1, pp. 7–74, Mar. 1998.
[11]. S. Biswas, "Science education in Indian secondary schools: Issues and challenges," *Journal of Indian Education*, vol. 39, no. 2, pp. 55–67, 2013.
[12]. D. D. Minner, A. J. Levy, and J. Century, "Inquiry-based science instruction—what is it and does it matter? Results from a research synthesis years 1984 to 2002," *Journal of Research in Science Teaching*, vol. 47, no. 4, pp. 474–496, Apr. 2010.
[13]. V. N. Lunetta, A. Hofstein, and M. P. Clough, "Learning and teaching in the school science laboratory: An analysis of research, theory, and practice," in *Handbook of Research on Science Education*, S. K. Abell and N. G. Lederman, Eds., Lawrence Erlbaum Associates, Mahwah, NJ, USA, 2007, pp. 393–441.
[14]. National Council for Teacher Education (NCTE), *National Curriculum Framework for Teacher Education*, NCTE, New Delhi, India, 2009.
[15]. UNESCO, *Science Education Policy Review: An International Perspective*, UNESCO, Paris, France, 2015.
[16]. K. Tobin, "The role of wait time in higher cognitive level learning," *Review of Educational Research*, vol. 57, no. 1, pp. 69–95, Mar. 1987.
[17]. M. Lazarowitz and P. Tamir, "Research on using laboratory instruction in science," in *Handbook of Research on Science Teaching and Learning*, D. L. Gabel, Ed., Macmillan, New York, USA, 1994, pp. 94–130.