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AN EXPLORATION OF DEMONSTRATION-BASED SCIENCE TEACHING PRACTICES AMONG SECONDARY SCHOOL TEACHERS

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RESEARCH ARTICLE

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Abstract
Demonstration-based teaching remains one of the oldest and most widely used pedagogical strategies in science education, yet its role in contemporary secondary classrooms is often taken for granted rather than critically examined. This paper undertakes a conceptual and document-based exploration of demonstration-based science teaching practices among secondary school teachers, situating the discussion within the broader shifts introduced by the National Education Policy 2020 (NEP, 2020), the National Curriculum Framework for School Education 2023 (NCF, 2023), and allied national programmes such as NISHTHA, NIPUN Bharat, PM SHRI Schools, and the National Curriculum Framework for Teacher Education (NCFTE, 2023). Using a phenomenological research approach supported by content and document analysis, the study synthesizes theoretical perspectives (Dewey, 1938; Piaget, 1970; Vygotsky, 1978; Bruner, 1966; Dale, 1969) with recent empirical evidence drawn from three international studies conducted outside India and three national studies conducted within India, published between 2020 and 2026. It concludes that demonstration-based teaching is not a relic of traditional pedagogy but a flexible, policy-aligned practice capable of advancing the experiential and competency-based aspirations of India's evolving science curriculum when supported by adequate infrastructure, teacher training, and reflective classroom practice.

Keywords: *Demonstration-based teaching, Secondary science education, Pedagogical philosophy, Curriculum implementation, Classroom context, National Education Policy 2020, Experiential learning*

Introduction

Science teaching at the secondary stage occupies a pivotal position in a learner's academic trajectory because it is at this stage that abstract scientific concepts, laboratory reasoning, and the habits of scientific inquiry begin to consolidate into durable cognitive structures. Historically, science pedagogy across the world, and particularly in India, has oscillated between didactic, lecture-based transmission of content and more participatory, activity-oriented approaches that place the learner at the centre of knowledge construction. Demonstration-based teaching has occupied a unique and somewhat ambiguous space within this spectrum: it is neither purely teacher-centred lecture nor fully learner-centred practical work, but a hybrid pedagogical act in which the teacher performs, models, or enacts a scientific phenomenon, procedure, or experiment while students observe, question, predict, and reason (Fung & Ng, 2026). The emergence of renewed scholarly interest in demonstration-based practices can be traced to a confluence of factors: the global recognition that hands-on, experiential learning improves scientific literacy (UNESCO, 2021); the persistent shortage of laboratory infrastructure, consumables, and trained laboratory assistants in a large proportion of secondary schools, especially in the Global South (Awuah & Siemoh, 2024); and the policy-level emphasis, in India, on experiential and competency-based learning articulated through the National Education Policy 2020 and the National Curriculum Framework for School Education 2023 (Ministry of Education [MoE], 2020; National Council of Educational Research and Training [NCERT], 2023).

The present moment makes the study of demonstration-based teaching especially urgent for three interconnected reasons. First, India's transition from a content-heavy, examination-driven curriculum to a competency-based, experiential model under NEP 2020 and NCF 2023 explicitly calls for a reduction in rote learning and an increase in hands-on, inquiry-oriented pedagogy, yet the practical realities of overcrowded classrooms, uneven laboratory infrastructure, and teacher workload mean that pure student-led experimentation is often not feasible at scale, making demonstration a pragmatic bridge strategy (MoE, 2020; NCERT, 2023). Second, comparative international evidence increasingly suggests that the pedagogical quality of implementation, rather than the mere structural distinction between demonstration and hands-on practical work, determines learning outcomes (Winkelmann et al., 2025), which repositions demonstration not as an inferior substitute for practical work but as a legitimate pedagogical choice requiring its own professional skill set. Third, national capacity-building programmes such as NISHTHA (National Initiative for School Heads' and Teachers' Holistic Advancement), NIPUN Bharat, and the NCFTE 2023 have begun to embed pedagogical training on demonstration, activity-based learning, and formative assessment into in-service and pre-service teacher education, signaling a policy recognition that teachers require structured support to use demonstration effectively rather than relying on ad hoc practice (MoE, 2021; NCERT, 2023). Taken together, these developments justify a focused, updated exploration of how secondary school science teachers actually understand, plan, and enact demonstration-based teaching within the evolving Indian and global policy landscape.

The Conceptual Framework

Drawing on Dewey's experiential learning, Piaget's constructivism, Vygotsky's mediated learning, Bruner's discovery learning and Dale's Cone of Experience, the framework positions demonstration as a mediating pedagogical act that renders abstract scientific ideas observable and discussable; it is timely because NEP 2020 and NCF 2023 demand experiential, competency-based pedagogy rather than rote transmission, recent global evidence (2020–2026) requires viewing demonstration as a flexible, context-sensitive strategy, post-pandemic hybrid and digital tools have expanded the material possibilities of demonstration, and NCFTE 2023 teacher-education reforms need insight into teachers' philosophies and constraints. The proposed study will therefore examine teachers' pedagogical philosophy behind choosing demonstration, their planning and implementation routines, the shaping influence of curriculum, textbooks and assessment, the effects of classroom context (class size, resources, support, student diversity), and the degree of alignment between current practices and the experiential aspirations of NEP 2020 and NCF 2023.

The Need of the Study: Demonstration's long history, systematic, policy-aligned research on its use at the secondary level remains scarce. Indian literature often privileges student-led practicals and treats demonstration as secondary, while recent international evidence (e.g., Winkelmann et al., 2025) challenges assumptions about its relative effectiveness—evidence not yet absorbed into Indian teacher education. With NEP 2020, NCF 2023, and programmes such as NISHTHA, PM SHRI and NIPUN Bharat pushing experiential, competency-based pedagogy, there is an urgent need to examine how secondary teachers currently conceptualise and enact demonstration so that training and policy implementation can be evidence-informed rather than assumption-driven.

The Statement of the Problem

The study entitled as "*An Exploration of Demonstration-Based Science Teaching Practices among Secondary School Teachers*."

The Significance of the Study: The study holds both theoretical and practical significance. Theoretically, it advances understanding of demonstration as a distinct pedagogical construct by integrating recent (2020–2026) national and international evidence with classical learning theories, moving it beyond a residual alternative to student practical work. Practically, it offers secondary science teachers a reflective tool for refining their philosophy and planning; supplies teacher educators implementing NCFTE 2023 with clear targets for demonstration-related competencies; informs curriculum developers and policymakers operationalising NEP 2020 and NCF 2023 about the curricular and assessment conditions that enable or hinder experiential pedagogy; and highlights for administrators the contextual factors (resources, class size, support) that must be addressed. Its rationale rests on the premise that effective pedagogical reform requires a nuanced grasp of current classroom practice, which this systematic exploration of teachers' philosophy, planning, curricular alignment and contextual experience aims to provide.

Research Objectives

O1: To explore the pedagogical philosophy of secondary school teachers regarding the use of demonstration-based teaching in science.
O2: To examine how secondary school teachers plan, prepare, and implement demonstration-based science teaching in classroom situations.
O3: To explore the influence of curriculum on teachers' use of demonstration-based science teaching.
O4: To examine the influence of classroom context on the implementation of demonstration-based science teaching practices.

Research Questions

RQ1: What is the pedagogical philosophy of secondary school teachers regarding the use of demonstration-based teaching in science?
RQ2: How do secondary school teachers plan, prepare, and implement demonstration-based science teaching in classroom situations?
RQ3: How does the curriculum influence teachers' use of demonstration-based science teaching?
RQ4: How does classroom context influence the implementation of demonstration-based science teaching practices?

Review of Related Literature

International Studies: Awuah and Siemoh (2024), working in a resource-constrained context in Ghana in which only a single microscope was available for instruction, used an action-research design with sixty respondents drawn from a population of seventy teacher trainees to test the effectiveness of the demonstration method for teaching microscope-handling and observation skills. Data gathered through tests and questionnaires indicated that trainees taught through demonstration outperformed those taught through lecture, even under conditions of severely inadequate teaching-learning materials. The authors recommended systematic in-service training in demonstration techniques for science teachers working in under-resourced settings, underscoring the practicality of demonstration for developing equipment-handling and observational competencies where apparatus is scarce. Winkelmann et al. (2025) finding is theoretically important because it suggests that the quality of classroom processes and the opportunities provided for cognitive processing of content matter more for learning outcomes than the structural distinction between teacher demonstration and student hands-on practical work, thereby challenging the assumption that student-led experimentation is inherently superior to well-implemented teacher demonstration in secondary physics teaching. Fung and Ng (2026) proposed the PEDDI framework, comprising pre-class materials, engagement, demonstration, discussion, and immediate teacher feedback, as a structured approach to enhancing the effectiveness of demonstration-based STEM instruction, concluding that the method remains valuable but highly context-specific and recommending targeted enhancements for policymakers, teacher-education institutions, and schools.

National Studies: Hoque and Dhar (2023) conducted a survey-based investigation in West Bengal examining secondary school physical-science teachers' attitudes toward student-centred instructional methods, with particular attention to demonstration. Their findings revealed a significant positive shift in attitude among teachers who had been exposed to the demonstration method, and, importantly, showed that the method produced equivalent learning benefits for male and female teachers, indicating that its effectiveness was not gender-biased. The study concluded that demonstration, understood as a student-centred approach, enhances interest and achievement in physical science and thereby supports its continued adoption within Indian secondary classrooms.

Risvan (2024) showed that while both approaches improved academic performance, the lecture-cum-demonstration group achieved significantly higher scores and demonstrated deeper conceptual understanding. Risvan (2024) argued that integrating interactive, demonstration-based strategies into otherwise lecture-driven instruction enhances both engagement and retention, and explicitly linked these findings to the aspirations of NEP 2020 for secondary science education in India.

Research Gap: Existing research mainly shows that demonstration improves student achievement, engagement and skills, usually through quantitative comparisons with lecture methods. Far less is known about teachers' pedagogical philosophy and beliefs that guide its use, their actual planning and classroom implementation routines, or how specific classroom realities (resources, class size, time, lab access, student diversity) shape the practice in secondary schools. Most studies remain outcome-focused and experimental; qualitative insight into teachers' lived experiences, curricular influences and contextual constraints is scarce. The present study fills this gap by exploring these four dimensions together.

The Methodology of the Study

Research Method: The study employed a phenomenological research method, which is appropriate for exploring the lived pedagogical experiences, beliefs, and philosophies of secondary school science teachers with respect to demonstration-based teaching. Phenomenology, as a qualitative approach, is concerned with understanding the essence of a phenomenon as it is experienced and interpreted by those who live it (Creswell & Poth, 2018), and is therefore well suited to addressing research questions concerned with teachers' pedagogical philosophy, planning routines, and perceptions of curricular and contextual influence.

Research Design: The research design adopted is content and document analysis. This design involves the systematic, qualitative examination of curriculum documents (including NEP 2020, NCF 2023, and NCFTE 2023), science textbooks and laboratory manuals prescribed by national and state boards, teacher-training modules associated with programmes such as NISHTHA and NIPUN Bharat, and the peer-reviewed and conference literature on demonstration-based teaching published between 2020 and 2026 (MoE, 2020, 2021; NCERT, 2023).

The Variables of the Study

- Independent variables (conceptual): the curricular provisions of NEP 2020 and NCF 2023, the availability of classroom and laboratory resources, class size, and institutional/administrative support, each of which is treated as a contextual factor shaping teachers' practice.
- Dependent variables (conceptual): teachers' pedagogical philosophy regarding demonstration, their planning and implementation practices, and the overall quality and frequency of demonstration-based science teaching enacted in the classroom.

Analysis and Interpretation

Exploration of the Pedagogical Philosophy of Secondary School Teachers Regarding Demonstration-Based Teaching

The reviewed literature suggests that secondary school science teachers' pedagogical philosophy regarding demonstration is generally rooted in a pragmatic, student-centred orientation rather than a purely transmissive one. Hoque and Dhar (2023) found that teachers exposed to the demonstration method developed significantly more positive attitudes toward student-centred pedagogy, suggesting that the underlying philosophy shifts from viewing teaching as content delivery toward viewing it as facilitated, observation-driven meaning-making. This aligns with Dewey's (1938) experiential learning philosophy, which holds that genuine learning arises from structured engagement with real or modelled experience rather than passive reception of information, and with Vygotsky's (1978) socio-cultural view of the teacher as a more knowledgeable other who models scientific reasoning within a learner's zone of proximal development. At the same time, the Indian Educational Review (2023–2024) study indicates that teachers' philosophy of demonstration is often practically motivated: teachers value demonstration not only as a pedagogical ideal but as a feasible compromise when full-scale student practical work is constrained by resources, safety concerns, or curricular time. The philosophy expressed by teachers, therefore, appears to be neither purely theoretical nor purely pragmatic but a blended stance in which demonstration is valued both for its capacity to make abstract concepts observable and for its adaptability to real classroom constraints, a duality strongly consistent with the NEP 2020 vision of experiential learning tailored to ground-level feasibility (MoE, 2020).

Table 4.1: Programme and Capacity-Building Evidence

Programme / Initiative	Key Features & Survey Findings	Support for Teachers' Philosophy
NCERT RIE Experiential Learning Interventions (e.g., for SRGs from J&K/Ladakh; chemical reactions exemplar)	Hands-on training using Kolb's cycle; teacher modelling and demonstration stages; capacity building for secondary science. Positive impact reported on teaching efficacy.	Directly builds the facilitated, observation-driven practice that Hoque & Dhar linked to attitude shifts.
NCERT Secondary Science Kits (SSK) utility study (2023–24; Haryana & Jharkhand)	Kits available in sample schools but often used primarily for teacher demonstration rather than full student work due to incomplete kits, large classes, and lack of training (53% teachers reported no formal kit training). Teachers requested hands-on workshops.	Confirms practical motivation: demonstration is the feasible default when resources/safety/time limit individual practicals – exactly as noted in the Indian Educational Review.
State surveys (Karnataka science teachers N=1203; Odisha secondary science)	High awareness of NEP experiential goals; many teachers request training in constructive/inquiry methods and practical approaches; resource and time constraints frequently cited.	Teachers' philosophy is policy-aligned yet grounded in classroom feasibility, reinforcing the blended stance.
Broader programmes (Samagra Shiksha, RMSA legacy, Mobile Science Labs / Lab-on-Bike pilots)	Emphasis on activity-based science; guided discovery and demonstration components; teacher orientation for hands-on methods.	Institutional programmes operationalise NEP 2020 by supporting demonstration as an accessible entry point to experiential learning.

Capacity-building programmes and kit-utilisation surveys show that teachers and systems prioritise demonstration as a realistic, high-impact method. Training efforts that include modelling and hands-on experience further shift attitudes toward student-centred pedagogy, while resource realities keep the approach pragmatic – fully consistent with the literature's description of a blended philosophy aligned with NEP 2020.

Explanation of How Secondary School Teachers Plan, Prepare, and Implement Demonstration-Based Science Teaching

The planning and implementation practices documented across the reviewed studies reveal a fairly consistent sequence: identification of a curricular concept requiring visual or experiential clarification, preparation or improvisation of apparatus, sequencing of the demonstration within the lesson (typically before or interwoven with explanation), and a concluding discussion or question-and-answer phase. Awuah and Siemoh (2024) illustrate how planning becomes especially critical under resource constraints, where teachers must carefully sequence a single piece of apparatus (in their case, one microscope) across an entire class, often rotating small groups through an observation station while managing the rest of the class through guided discussion. Fung and Ng's (2026) PEDDI framework, comprising pre-class materials, engagement, demonstration, discussion, and immediate feedback, offers a structured articulation of best-practice implementation, suggesting that effective demonstration is not a spontaneous act but a carefully staged instructional sequence requiring deliberate pre-class preparation and post-demonstration consolidation through discussion and feedback. The Indian Educational Review (2023–2024) findings similarly show that many Indian secondary teachers either bring laboratory materials into the classroom or transport students to the laboratory specifically to enact demonstrations of concepts such as magnetic fields, pressure variation, and inertia, indicating a deliberate, planned integration of demonstration into the lesson structure rather than incidental or improvised use. Collectively, these findings suggest that effective implementation depends heavily on teachers' capacity for advance planning, resourcefulness in apparatus preparation, and skill in structuring the discussion that follows the demonstration, all of which are addressed as target competencies within the NCFTE 2023 framework for teacher preparation (NCERT, 2023).

Table 4.2: Secondary School Teachers Plan, Prepare, and Implement Demonstration-Based Science Teaching

Programme / Initiative	Implementing Body / Location	Key Features Supporting Planning, Preparation & Implementation	Evidence of Sequence & Resourcefulness	Source / Reference
NCERT / RIE Experiential Learning Capacity-Building for	Regional Institute of Education (RIE), NCERT Ajmer	Teachers trained in Kolb's experiential cycle: concrete experience (demonstration), reflective observation, abstract	Structured pre-class preparation of apparatus; sequencing of demonstration within	NCERT RIE programme reports; Sharma & Pareek

Secondary Science Teachers (e.g., chemical reactions exemplar for SRGs from J&K & Ladakh)		conceptualisation, active experimentation. Explicit focus on advance planning of materials, teacher modelling, and post-demonstration discussion.	lesson; guided discussion and feedback phases. Builds teacher capacity for deliberate integration rather than spontaneous use.	(experiential interventions for in-service teachers)
NCERT Secondary Science Kits (SSK) Utilisation & Orientation Programmes (Haryana, Jharkhand & national rollout)	Division of Educational Kits, NCERT; Samagra Shiksha	Kits supplied for Classes 9–10; teacher orientation on apparatus use. Surveys showed frequent teacher-led demonstration (due to incomplete kits or large classes) rather than full student practicals. Training emphasises improvisation and sequencing limited apparatus.	Teachers plan by selecting key concepts (e.g., magnetic fields, pressure, inertia), prepare/improvise kit items or local materials, bring apparatus to classroom or take students to lab, rotate groups where needed, and conclude with discussion.	NCERT SSK utility study (2023–24); teacher interview findings
STARS Project / Samagra Shiksha In-service Teacher Training Modules (Upper Primary & Secondary Science)	Samagra Shiksha (Himachal Pradesh and other STARS states); World Bank-supported	Modules focus on pedagogical processes for learning outcomes: hands-on activities, demonstration of concepts, apparatus preparation, and post-activity discussion/Q&A. Includes suggestive lesson sequences aligned with NCERT textbooks.	Explicit guidance on advance identification of concepts needing visual clarification, preparation of low-cost/TLM materials, sequencing demonstration before or interwoven with explanation, and consolidation through discussion.	STARS In-service Teacher Training Module – Science (Upper Primary); Samagra Shiksha training reports
UP Government "Learning by Doing" Training for Science & Math Teachers (under Samagra Shiksha & PM SHRI)	Uttar Pradesh Samagra Shiksha; Institute of Entrepreneurship Development / Deen Dayal Upadhyay State Rural Development Institute, Lucknow (with UNICEF & STAR Forum-Vigyan Ashram technical support)	Phased residential TOT and teacher training (2025–26) emphasising experiential methods, apparatus improvisation, and classroom demonstration sequences for secondary science.	Teachers learn to plan limited-resource demonstrations (e.g., single apparatus rotation), prepare low-cost materials, stage the demonstration, and structure follow-up discussion — directly addressing resource constraints.	UP Govt. notifications & training rollout (2025–26)
IISER Pune / PM SHRI Capacity-Building Workshops for Science Teachers (e.g., Chhattisgarh teachers)	IISER Pune Science Activity Centre in collaboration with Samagra Shiksha (PM SHRI)	5-day residential hands-on workshops: low-cost experiments, teacher demonstration techniques, DIY apparatus preparation, and classroom sequencing of activities.	Focus on pre-class preparation of simple apparatus, engagement via demonstration, discussion of observations, and immediate feedback — mirroring structured frameworks such as PEDDI.	IISER Pune workshop documentation (2025)
Royal Society of Chemistry / Samagra Shiksha Workshops for Secondary Science Teachers (e.g., Sankardev College, Meghalaya)	RSC UK + Samagra Shiksha + local colleges	Hands-on training in inquiry-based techniques, preparation of low-cost teaching resources for classroom experiments, and active demonstration methods.	Teachers practice identifying concepts, improvising apparatus from readily available materials, sequencing demonstrations, and facilitating post-demo discussion.	Workshop reports (2024)

CIET-NCERT Virtual Labs Integration Training (Science & Mathematics teachers)	CIET-NCERT, New Delhi	Training on integrating virtual/physical demonstrations for experiential learning under NEP 2020; includes planning digital + physical apparatus sequences and post-demo assessment/feedback.	Supports hybrid preparation (physical apparatus + virtual demos) and structured implementation with discussion and immediate feedback.	CIET-NCERT training programme (March 2026)
Diploma Programme in Science Education (DPSE) – NCERT	NCERT	Professional development for in-service secondary science teachers emphasising process-oriented teaching, practical components, apparatus handling, and pedagogical sequencing of demonstrations.	Practical modules require trainees to plan and perform experiments/demonstrations at school or home, reinforcing advance preparation and structured classroom use.	NCERT DPSE Programme Guide

Programmes under NCERT, Samagra Shiksha, STARS, PM SHRI, and IISER explicitly address resourcefulness (rotating groups, low-cost improvisation, bringing materials into the classroom or moving students to the lab — matching Indian Educational Review 2023–2024 findings). Structured staging (pre-class materials → engagement → demonstration → discussion → feedback) aligns with frameworks such as PEDDI (Fung & Ng). Collectively they target the advance-planning, apparatus-preparation, and post-demonstration discussion competencies highlighted in NCFTE 2023 / NEP 2020 teacher preparation frameworks, providing robust programme-level evidence for the planning and implementation practices described.

Exploration of the Influence of Curriculum on Teachers' Use of Demonstration-Based Science Teaching

Curriculum emerges across the reviewed literature and policy documents as a decisive determinant of the frequency, style, and depth of demonstration-based teaching. The NCF 2023 explicitly foregrounds experiential and competency-based pedagogy, discouraging rote memorization and encouraging teachers to design lessons around observable, activity-linked learning outcomes, which in turn increases curricular legitimacy and time allocation for demonstration-based teaching (NCERT, 2023). Risvan's (2024) study, presented at a conference explicitly framed around NEP 2020 and teacher-education innovation, demonstrates how curricular reform discourse is already shaping empirical research design, with the lecture-cum-demonstration method being framed as directly responsive to policy expectations for interactive, competency-based instruction. However, the Indian Educational Review (2023–2024) study also reveals variation across examination boards (SSLC, CBSE, ICSE, IGCSE) in the extent to which demonstration is embedded within prescribed practical curricula and assessment schemes, suggesting that curricular influence is not uniform but mediated by board-specific syllabus design, textbook content, and assessment weightage given to practical or observation-based skills. Internationally, Winkelmann et al. (2025) situate their comparison of experimenting practices within the German physics curriculum's specific unit on geometrical optics, illustrating how curriculum topic structure itself can determine whether demonstration or student practical work is the more feasible or pedagogically appropriate choice. Overall, the evidence indicates that curriculum operates as both an enabler and a constraint: policy-level curricular reform (NEP 2020, NCF 2023) provides philosophical and structural encouragement for demonstration-based, experiential teaching, while board-specific syllabus design, textbook framing, and assessment patterns determine the practical extent to which teachers translate this encouragement into classroom practice.

Table 4.3: Evidence Supporting the Influence of Curriculum on Teachers' Use of Demonstration-Based Science Teaching

Evidence / Key Finding	Description of Influence on Demonstration-Based Teaching	Implemented Programme / Framework / Curriculum	Source
Policy-level encouragement of experiential & competency-based pedagogy	NCF 2023 prioritises observable, activity-linked learning outcomes over rote memorisation. This raises the curricular legitimacy of demonstration methods and increases allocated time for teacher-led demonstrations as part of experiential science teaching.	National Curriculum Framework for School Education (NCF-SE) 2023 (implements NEP 2020 vision)	NCERT / Ministry of Education (2023); supporting analyses of experiential learning strategies under NCF 2023
Framing of lecture-cum-demonstration as policy-responsive pedagogy	Curricular reform discourse under NEP 2020 shapes research and teacher-education practice; the lecture-cum-demonstration method is positioned as interactive and competency-oriented, encouraging its adoption in science classrooms.	NEP 2020 + associated teacher-education reforms and conference-framed studies on innovative pedagogy	Risvan (2024) study (explicitly framed around NEP 2020 and teacher-education innovation); B.Ed. syllabi incorporating lecture-cum-demonstration under NEP 2020

Variation by examination board in embedding of demonstration	Demonstration is more or less embedded depending on board-specific syllabus design, textbook content, and weightage given to practical/observational skills. Higher use of classroom demonstrations reported overall (26/30 teachers), but frequency and depth differ (e.g., SSLC, CBSE, ICSE, IGCSE, KFI).	Board-specific curricula and practical assessment schemes (SSLC/state boards, CBSE, ICSE, IGCSE)	Indian Educational Review (July 2023–January 2024) study on pedagogical practices of science across Indian school systems (Jeena Anne K.)
Topic structure within curriculum determines feasibility of demonstration vs. student practical work	In the German physics curriculum unit on geometrical optics, the specific topic structure makes teacher demonstrations a more feasible or pedagogically appropriate choice than open student practical work for certain learning goals (content knowledge acquisition).	German secondary physics curriculum (geometrical optics unit)	Winkelmann et al. (2025) longitudinal experimental study comparing three experimenting practices (demonstrations, guided practical work, less-guided practical work)

Curriculum functions as both enabler and constraint. Broad policy frameworks (NEP 2020 → NCF 2023) create philosophical and structural support for demonstration-based, experiential science teaching. At the same time, concrete implementation—board syllabi, textbook framing, assessment weightage, and topic-specific curriculum design—determines how frequently, in what style, and to what depth teachers actually use demonstrations in classrooms.

Examination of the Influence of Classroom Context on the Implementation of Demonstration-Based Science Teaching Practices

Classroom context, encompassing resource availability, class size, and institutional support, is repeatedly identified across the reviewed literature as a critical mediating factor in the successful implementation of demonstration-based teaching. Awuah and Siemoh's (2024) study, conducted in a Ghanaian setting with only a single microscope available, offers perhaps the starkest illustration of resource constraint shaping implementation, yet also demonstrates that skilled teachers can adapt demonstration-based strategies even under severe scarcity, provided they receive appropriate in-service training. Fung and Ng's (2026) systematic review corroborates this pattern at a broader scale, identifying resource constraints and preparation demands as recurring challenges across the forty-nine studies reviewed, alongside benefits that depend heavily on adequate classroom conditions for realization. In the Indian context, the Indian Educational Review (2023–2024) study indicates that access to a functional laboratory, or at minimum, portable laboratory materials, strongly influences whether teachers are able to enact demonstrations for specific topics such as magnetic fields or pressure variation, reflecting the broader infrastructural variability across Indian secondary schools that NEP 2020 seeks to address through investments in school infrastructure and resource-sharing models such as PM SHRI Schools (MoE, 2020). Class size and institutional support also emerge as significant contextual variables: large class sizes constrain the visibility and interactivity of demonstrations, particularly for delicate or small-scale phenomena, while institutional support in the form of laboratory assistants, administrative encouragement, and scheduling flexibility enables more elaborate and frequent demonstration-based lessons (Fung & Ng, 2026). These findings collectively suggest that classroom context does not merely moderate the effectiveness of demonstration-based teaching but fundamentally shapes whether, how often, and in what form such teaching can occur at all, underscoring the importance of infrastructural and institutional investment alongside pedagogical training in efforts to strengthen experiential science education under NEP 2020 and NCF 2023.

Table 4.4:: Evidence Supporting the Influence of Classroom Context on the Implementation of Demonstration-Based Science Teaching

Evidence / Key Finding	Description of Influence on Demonstration-Based Teaching	Implemented Programme / Framework / Initiative	Source
Severe resource scarcity can be mitigated by skilled demonstration with training	Even with only a single microscope available, the demonstration method significantly improved students' performance in microscope use compared to lecture methods. Adaptation is possible under extreme scarcity when teachers receive targeted in-service training.	In-service teacher training programmes focused on demonstration methods in resource-limited settings (Ghana Colleges of Education context)	Awuah & Siemoh (2024) action research study, Abetifi Presbyterian College of Education, Ghana
Resource constraints and preparation demands as recurring barriers; benefits depend on adequate classroom conditions	Across 49 studies, limited resources, high preparation time, large class sizes (reducing visibility/interactivity), and lack of institutional support (lab assistants, scheduling flexibility, administrative encouragement)	Broader STEM education improvement recommendations for policymakers, universities and schools arising from systematic review findings	Fung & Ng (2026) PRISMA systematic literature review (49 studies) on benefits and challenges of the demonstration

	emerge as major challenges. Adequate conditions are essential for realising the benefits of demonstrations.		method in STEM education
Access to functional laboratory or portable materials determines feasibility of topic-specific demonstrations	Teachers' ability to conduct demonstrations (e.g., magnetic fields with magnets, pressure variation with water-filled bottles) depends heavily on access to a functional laboratory or portable materials. Infrastructural variability across Indian secondary schools directly shapes frequency and form of demonstration use.	Board-specific practical science curricula and existing school laboratory infrastructure (SSLC, CBSE, ICSE, IGCSE, etc.)	Indian Educational Review (July 2023–January 2024) study on pedagogical practices of science across Indian school systems
Systemic infrastructural investment and resource-sharing to enable experiential/demonstration-based teaching	Large-scale upgrading of science laboratories, provision of science & maths kits, integrated labs, and resource-sharing models address the infrastructural gaps that constrain demonstration-based teaching, supporting NEP 2020 goals of experiential science education.	PM SHRI Schools (PM Schools for Rising India) scheme – centrally sponsored programme to develop exemplar schools with fully equipped science labs, kits, ICT facilities, and resource-sharing (hub-and-spoke) models	Ministry of Education (MoE, 2020 onwards); NEP 2020 implementation via PM SHRI (approved 2022, ongoing saturation of labs and kits)
Class size and institutional support as critical enablers	Large class sizes limit visibility and interactivity of demonstrations (especially small-scale or delicate phenomena). Institutional support (lab assistants, flexible scheduling, administrative encouragement) enables more elaborate and frequent demonstration lessons.	School-level institutional support mechanisms and infrastructure strengthening under NEP 2020 / Samagra Shiksha and PM SHRI	Fung & Ng (2026) systematic review; linked to NEP 2020 / NCF 2023 emphasis on experiential pedagogy and infrastructure investment

Classroom context (resources, class size, institutional support) does not merely moderate effectiveness—it fundamentally determines whether, how often, and in what form demonstration-based science teaching can occur. Policy responses such as PM SHRI Schools and associated infrastructure investments under NEP 2020 / NCF 2023 directly target these contextual barriers to enable wider and deeper use of demonstration-based experiential teaching.

Major Findings

- Secondary school science teachers' pedagogical philosophy toward demonstration is predominantly a blended, pragmatic-constructivist stance that values demonstration both as an experiential, student-centred pedagogical ideal and as a practically feasible compromise under resource and time constraints (Hoque & Dhar, 2023; Indian Educational Review, 2023–2024).
- Effective demonstration-based teaching follows a discernible planning sequence involving concept identification, apparatus preparation or improvisation, structured in-class enactment, and post-demonstration discussion, as formalized in frameworks such as PEDDI (Fung & Ng, 2026) and evidenced in resource-constrained implementation strategies (Awuah & Siemoh, 2024).
- Curriculum reform at the policy level, particularly NEP 2020 and NCF 2023, provides strong philosophical and structural encouragement for experiential, demonstration-based pedagogy, but the actual extent of curricular influence on classroom practice is mediated by board-specific syllabus design, textbook content, and assessment weightage (NCERT, 2023; Risvan, 2024).
- Comparative international evidence indicates that demonstration does not inherently produce inferior learning outcomes relative to student-led practical work; rather, the quality of classroom implementation and opportunities for cognitive engagement with content are the decisive factors in determining learning gains (Winkelmann et al., 2025).
- Classroom-context factors, including resource availability, class size, and institutional support, exert a powerful mediating influence on the frequency, quality, and feasibility of demonstration-based teaching, with resource-scarce contexts requiring adapted, teacher-driven improvisation strategies to sustain effective practice (Awuah & Siemoh, 2024; Fung & Ng, 2026).
- Demonstration-based teaching, far from being a pedagogically outdated technique, aligns closely with the experiential and competency-based aspirations of NEP 2020 and NCF 2023 when it is deliberately planned, contextually adapted, and professionally supported through in-service training programmes such as NISHTHA and structured teacher-education reforms under NCFTE 2023 (MoE, 2020, 2021; NCERT, 2023).

Conclusion

This exploration of demonstration-based science teaching practices among secondary school teachers has shown that demonstration remains a pedagogically significant, empirically supported, and policy-relevant instructional strategy within contemporary science education, both internationally and in India. Rather than representing a lesser or outdated alternative to student-led practical work, demonstration functions as a distinct pedagogical practice with its own philosophy, planning demands, curricular sensitivities, and contextual requirements, each of which must be understood on its own terms rather than assessed solely against the benchmark of independent practical work. The synthesis of six empirical studies published between 2020 and 2026, alongside classical and contemporary learning theory and the provisions of NEP 2020, NCF 2023, and NCFTE 2023, indicates that demonstration-based teaching, when grounded in a reflective pedagogical philosophy, supported by deliberate planning routines, encouraged by curricular design, and enabled by adequate classroom context, can meaningfully advance the experiential and competency-based goals of contemporary science education. At the same time, the persistent challenges of resource scarcity, large class sizes, and uneven teacher preparation identified across the reviewed literature signal that realizing this potential at scale requires coordinated investment in infrastructure, sustained in-service training through programmes such as NISHTHA and NIPUN Bharat, and curricular and assessment reforms that explicitly recognize and reward demonstration-based competencies. Future empirical research, particularly field-based qualitative and mixed-methods studies conducted directly with secondary school teachers across diverse Indian states and school types, would further enrich the phenomenological and document-based understanding developed in this paper, and is recommended as a natural extension of the present exploration.

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