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Pedagogical practices of secondary school science teachers in bihar: A survey-based analysis

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Abstract
The present paper highlights the pedagogical practices of science teachers of secondary schools and the problems faced by them in teaching science curriculum in the classroom scenario in Nalanda district, Bihar. The study is descriptive in nature, using a survey method, complemented with classroom observations and a semi-structured interview schedule, which were administered in 20 secondary schools out of which, one science teacher was chosen from each of these schools. The data analysis shows that science education in the selected schools was teacher-centered and based on lecturing, less usage of group work, experimentation, inquiry-based teaching, project work, and information and communication technology (ICT). The usage of the blackboard was very common, in the classroom teaching but it was observed that almost no usage teaching learning materials such as charts, videos, projector, and laboratory supported learning. Aligned with the challenges they encountered, teachers cited infrastructural constraints, limited functionality of laboratories, extra administrative tasks, teacher shortage, and student absenteeism as the main challenges to effective science teaching. The paper emphasizes the need for systemic support for infrastructure, classroom materials, technology integration, and school level instructional leadership, in addition to teacher training, to improve science pedagogy in under-resourced secondary schools.

Keywords: Science education, pedagogy, secondary school teachers, classroom practices, inquiry-based teaching, bihar

Introduction

The quality of science learning is dependent on appropriate use of teaching methods and selection of suitable teaching learning materials for the particular lesson. Although curricular materials may promote inquiry, experimentation, and activity-based learning, and encourage student participation, classroom activities might still most of the classrooms are lecture-dominated, note taking, and factually oriented (Sturrock, 2025) [20]. Studies in recent years, it has been shown that the implementation of inquiry-based science teaching will produce a scientific understanding, science interest, and scientific creativity of students, but still, it requires consistency from teachers in providing support, pedagogical content knowledge, and enabling school conditions (Urdanivia Alarcon *et al*, 2023 [22] Correia & Harrison, 2020) [8].

The policy intention–reality gap continues to be a persistent challenge in science education.

The gap is particularly prominent in low-resourced school settings where science teachers may lack in access to extensive laboratory equipment, teaching materials and have excessive administrative workloads (Sharma, 2025) [19]. The results of studies conducted in various contexts have demonstrated that adopting an inquiry approach to science teaching is challenging in low-resourced schools unless the teacher is given specific professional development and contextual support (Akuma & Callaghan, 2018 [1,2] McKeown *et al*., 2015) [14,15]. New evidence also points to the importance of the ability of teachers to internalize their beliefs and then translate them into formative assessment practices, classroom discourse and opportunities for students to be autonomous (Correia & Harrison, 2020) [8].

Science education in secondary schools would not only be the transfer of facts and figures but should also enable students to acquire scientific literacy, inquiry skills, problem-solving skills and the ability to use scientific thinking in their day-to-day life (Sutiani et al., 2021 [21] Urdanivia Alarcon et al., 2023) [22]. The importance of science teaching in such a context becomes a focus of the intellectual and civic development of the learners, especially in school systems striving to prepare learners for a rapidly changing world (Crawford, 2014). The results are highly relevant to research on the actual pedagogical practice.

In today's global and national context of science education, student-centered and active learning has become a strong focus, using an inquiry-based learning model to develop scientific literacy and creativity (Goodrum, 2006 [10] Sharma, 2024) [19]. This vision is clearly supported by the current policy reforms in India, such as the National Education Policy (NEP) 2020 and the National Curriculum Framework for School Education (NCF-SE 2023), which emphasize the need to move beyond rote memorization and towards more practical, experimental, and technologically advanced approaches to learning. Despite this there is a significant "policy-to-practice" gap, especially in the historically disadvantaged and under-resourced state school systems where traditional expository or lecture-based approaches to instruction still dominate.

This paper also stresses that science, besides being a body of knowledge, is a way of thinking about nature around them that is expressed in science inquiry and involves evidence, reasoning and observation. The present study aims at analyzing pedagogical practices of secondary school science teachers in Nalanda district, Bihar and their challenges in the process of transacting science curriculum.

Review of Related Literature

In many educational studies, teachers in theory support active and inquiry learning, but in practice carry out their teaching in an expository manner (Goodrum, 2006) [10]. This mismatch between policy and classroom is especially evident in developing settings where there are strong traditions of rote-learning. On the other hand, when used successfully, inquiry-based learning in Secondary science classrooms results in substantial improvements in students' cognitive outcomes as well as their scientific creativity (Sharma, 2024) [15], which means that inquiry is not only a policy ideal but it is also a pedagogical approach that has observable outcomes in student learning.

However, recent studies have shown that the quality of the inquiry-based teaching, rather than its presence, is more important. Inquiry should be more than an activity or a process of discovery; it should be an active process of student engagement with driving questions, empirical evidence, and scientific reasoning (Areepattamannil, 2025) [4].

Student-centered and teacher-centered science instruction are contrasted in the research literature, and this comparison may help explain these structural differences. Hofstein & Lunetta, (2004) [11] referred to the way orientation in classrooms affects students' approach to content, their involvement in the classroom, and the extent to which students are given opportunities to think, discuss, and use scientific concepts. In strongly teacher-led classrooms, students can get information efficiently for rote assessments, but not the forms of dialogic and investigative learning that facilitate a deeper conceptual understanding.

Beliefs of the teacher and teacher preparation also influence these classroom dynamics (Mahmood, 2008) [13]. The findings regarding teachers' beliefs indicate that teachers who tend to see themselves as facilitators are more likely to promote open or guided inquiry (Williams et al., 2017 [23] McKeown et al., 2015) [14,15], whereas teachers with a very directive belief set are correlated with much narrower instructional practices and traditional, memory-based assessment practices (Akuoko, 2025 [3] Bou Jaoude & Saad, 2012). Additionally, research on science teacher preparation in recent years suggests that the Pedagogical Content Knowledge (PCK) and inquiry orientations are also important factors in supporting teachers' action in realising high-level reform goals.

The incorporation of technologies has become another factor that determines modern science teaching. The development of science teachers' Technological Pedagogical and Content Knowledge (TPACK) is an important factor in enhancing their capacity to prepare the scientific inquiry in modern classrooms (Khan, 2024) [12]. The development of technology-enhanced inquiry pedagogies (e.g., virtual laboratories) indicates that digital technologies can enhance the motivation of students and their participation in a pedagogical framework for simulated inquiry even in rural schools, when used as part of a structured pedagogical framework and not as a standalone approach (Shambare & Jita, 2024) [17].

Lastly, the literature on professional development highlights the need for ongoing and context-specific support to change long-standing pedagogical patterns. Professional development models that involve multiple professionals, such as lesson study and inquiry planning with technology integration, have been shown to enhance teacher confidence in teaching and to pave the way for inquiry teaching (Coenders & Verhoef, 2018 [7] Richman et al., 2019) [16]. But, even in participatory processes, infrastructure challenges and extreme time limits are significant constraints to change (Akuma & Callaghan, 2018 [1,2] Benitez, et al. 2026) [5].

Objectives of the Study

1. To study the pedagogic practices of secondary school science teachers.
2. To study the difficulties faced by the secondary school science teachers in transacting science in their class.

Research Questions

1. What are the pedagogical practices being used by science teachers in class?
2. What are the difficulties faced by the science teachers in transacting curriculum in science classroom?

Methodology

The paper is based on empirical data gathered using the survey method and aimed at exploring pedagogical practices of secondary school science teachers and challenges they encountered in the implementation of the science curriculum. The population of the study was science teachers of secondary schools in Nalanda district of Bihar and the sample was 20 science teachers from 20 secondary schools selected from the population. Twenty schools were sampled by random sampling and one science teacher from each of these schools was sampled for the study. All 20 teachers in the study were anonymized with codes ranging from 'A' to 'T', with the aim of analyzing the data and maintaining anonymity for the teachers. There are 20 teachers of which 10 are from biology, 6 are teachers of chemistry and 4 are teachers of physics.

Data was gathered using two main instruments: one was the teacher interview schedule which includes items relevant to the problems encountered by the teachers, and the other was the classroom observation schedule which was prepared to record the actual classroom situation while conducting science lessons. The data collection process was undertaken in several stages, such as access to schools and gaining consent, interviewing, and classroom observations.

Data analysis and Findings

The interpretation of the data is presented in two sections. The first section provides an explanation of the different pedagogical practices used by teachers as a result of the data gathered using the observation schedule. The second section focuses on science teachers' perceived difficulties in teaching science that are identified from the information gathered from the interview schedule. The second section is about the perceived difficulties of the science teachers in teaching science based on the information obtained from the interview schedule. It also discusses the different aspects that can be responsible for these difficulties.

Section 1: Pedagogical Practices Adopted by Teachers

The section 1 covers the Pedagogical Practices adapted by the teachers which includes 4 kinds of subs-sections such as Introducing the lesson, Resource Materials used during Lesson Transaction, Method of Teaching Used by Teachers, Frequency of the Type of Questions asked by the Teacher during the Lesson Transaction.

Sub-section 1: Introducing the Lesson

This sub-section deals with the introduction of lesson in the classroom by the teachers. There are differences in each teacher way of introducing the lesson. In that unique way of introducing the lesson in the classroom was categorized by the following five types and tabulated the same.

Table 1: Introducing the lesson

Sl. No	Strategies Adopted to Introduce the Lesson	Number of Teachers Using the Strategy	Teachers
01	Directly starting the topic	12	A, C, D, E, G, H, J, L, M, P, R, S
02	Reviewing the previous lesson	10	B, D, E, F, G, H, J, N, O, Q
03	Posing a problem⁄asking a question	9	A, B, C, F, G, I, J
04	Showing power point⁄video narrating a situation	00	-
05	Others	05	B, C, E, F, T

The table 1 depict that different strategies adopted by science teachers to introduce a lesson. The results showed that the method most commonly adopted was to "start the topic" directly without any specific questions, as is the case with 12 teachers (A, C, D, E, G, H, J, L, M, P, R, and S). This implies that most teachers preferred to start the lesson without any motivational technique and/or introductory activity. Reviewing the previous lesson was the second most common strategy used, with 10 teachers (B, D, E, F, G, H, J, N, O, Q) using this approach. This was useful for teachers to relate the new information to what students had already learned and to give continuity in teaching. A few teachers (9) mentioned that they had posed a problem or question at the start of the lesson (A, B, C, F, G, I and J). The strategy is learner centred because it allows learners to think critically and actively engage in the learning process. However, the use of them was relatively low, suggesting that enquiry-based lesson introductions were not widely used. The results of this study indicated that teachers' ways of introducing the lesson mainly used conventional approaches, namely introducing the theme of the lesson and summarizing the previous lesson, and there was no use of inquiry-based and technology-supported approaches for the introduction of the lesson.

Sub-section 2: Resource Materials used during Lesson Transaction

There were 20 teachers, 18 of whom used the blackboard, as their basic teaching instrument, and another four teachers used both the textbook and blackboard in the classroom during instruction. No teachers used charts, videos or any other multimedia resources. The main points for the lesson were written on the blackboard by most of the teachers while some drew diagrams; such as the parts of a flower, an animal cell and a plant cell, to explain scientific concepts. The teacher of physics deduced mathematical equations on the blackboard and clarified physical concepts. Only six to eight teachers out of the twenty used the blackboard systematically with writing that was clear and legible even from the last bench. The four teachers who were referring to the textbook also wrote down the important points on the blackboard. In general, the blackboard was utilized well for the teaching and learning process in the class and students recorded the topic and important points in their notes. All teachers did not use coloured chalk. Some teachers also taught in Hindi and English language and used scientific terms like motion, mitochondria, cell in English.

Sub-section 3: Method of Teaching Used by Teachers

Selecting the appropriate teaching method for the particular lesson is the biggest challenge for any teacher. It is important to choose the suitable teaching method before the classroom transaction. As a part of the present research 13 type of teaching methods are identified and tabulated below.

Table 2: Method of Teaching Used by Teachers

Sl. No	Methods	Number of Teachers	Teachers
01	Lecture	20	A,B,C,D,E,F,G,H,I,J,K,L,M,N,O,P,Q,R,S,T
02	Question and Answer	12	A,B,C,F,I,J,K,LN,O,Q,R
03	Whole class discussion	12	A,B,C,D,E,F,G,H,M,N,O,T
04	Small Group Discussion	00	-
05	Brain Storming	04	A,C,D,G
06	Demonstration	01	E, N,Q
07	Experimentation	00	-
08	Group activities	00	-
09	Debate	00	-
10	Presented by Student	00	-
11	ICT Based Learning	00	-
12	Inquiry Based Learning	00	-
13	Any Other	00	-

The 20 science teachers showed a strong reliance on teacher-centered instruction as it was mentioned in table 2 that all the teachers used the lecture method. 12 teachers (60%) employed the question-and-answer method while the whole class discussion method was used by 12 (60%) teachers, with moderate use of interactive teaching practices. Only 4 teachers used brainstorming and 3 teachers used demonstration. None of the teachers, however, employed the small group discussion, experimentation, group activity, debate, student presentation, small group learning with ICT or inquiry-based learning. The results indicated that science teachers primarily used traditional teaching approaches with lesser extent of the use of learner-centered pedagogical approach, activity-based pedagogical approach and technology-supported pedagogical approach

Sub-section 4: Frequency of the Type of Questions asked by the Teacher during the Lesson Transaction:

The results show that of 20 teachers, 16 asked mostly factual or knowledge type questions. Chemistry teachers requested students to define an atom, molecule, biology teachers requested to define a cell, reproduction and Physics teachers requested to explain motion, distance and displacement. All teachers-started classroom discussions and reflective questions did not foster higher order thinking. Likewise, none of the teachers had asked reflective questions for the students to consider after class. But 6 teachers were more actively involving the students in the teaching–learning process: They asked questions during the lesson, and they wrote important definitions, formulae and diagrams from the blackboard, including the definition of atoms and molecules and its corresponding pictures.

Section 2: Difficulties Perceived by Science Teachers while Teaching Science

Science teachers face numerous difficulties in managing classroom situations, both in implementing curriculum and assessing students' learning; and in their own professional development. The difficulties faced by science teachers were discussed in the present study by observing their classrooms and conducting interviews.

The results show that there was no major or complex problem faced by the teachers, but the problems reported were mainly basic and contextual ones. Lack of infrastructure was one of the most frequent issues. The majority of teachers complained regarding the absence of conducive science laboratories and necessary equipment for scientific work. While some schools possessed laboratory facilities, they were either under-equipped or inoperable and hamper teachers to perform practical activities and deliver hands-on learning opportunities to their students.

The lack of motivation, due to excessive non-teaching responsibilities and less professional development exercises, was another challenge. In the interviews, a number of teachers indicated that they had to engage in administrative activities and school events regularly, which resulted in a lack of time and energy in classroom teaching.

Teacher shortage also emerged as a significant issue. As there were not enough teachers for the class, it meant there was a greater amount of work on the shoulders of the teacher, who were sometimes required to teach more than one class. One teacher observed that there were instances in which one teacher would joint two classes for instruction. This augmented workload constrained the capacity for innovative classroom pedagogical approaches and for teachers to be effective in classroom assessment.

Another frequent comment was that students were not attending regularly. It was believed that excessive absenteeism had a negative impact on the teaching and learning process, and decreased student academic achievement. They also reported that the regular attendance and the active participation of the students improved their motivation and effectiveness as teachers.

Regarding the supplementary teaching materials, the majority of teachers indicated that they did not need extra materials to teach science in secondary school because they felt that they were experienced enough for the task, with the remaining teachers indicating that they would require them. Some teachers recognised that they needed to access reference materials on the introduction of new topics. The results further indicate that many teachers used mainly the SCERT textbooks and used the supplementary materials, like Internet or other reference materials, less frequently. This suggests reliance on textbooks as a form of learning support materials and low desire for continuous professional learning.

Discussion

The empirical results obtained from Nalanda district, Bihar, show that the policy-to-practice gap is very sharp between the progressive policy of NEP (2020) and the investigation-based policy of NCF-SE (2023), and the classroom realities. The study of science in secondary schools has been shown from the literature that structured guided inquiry is able to produce high achievement in science creativity and scientific literacy (Areepattamannil, 2025 [4] Sharma, 2024) [15]. The observed classroom in science is totally teacher centered and expository type of teaching. The fact that 100% of the 20 teachers surveyed used the lecture method and that 80% of them relied on low order questions that were purely factual indicates a very narrow focus on teaching aimed at rote learning and not at conceptual understanding (Hofstein & Lunetta, 2004) [11]. This instructional loop is perpetuated by the total lack of ICTs and experimental void, not only due to the lack of infrastructure, but also to the beliefs of traditional teachers who prefer directive learning using textbooks (Akuoko, 2025 [3] McKeown et al., 2015) [14,15]. Most importantly, the interview information reflects systemic tension on an overwhelming scale: insufficient teachers to run active-learning frameworks in most classes, high student absenteeism, and the sheer amount of non-teaching administrative work that teachers have with little or no cognitive or structural space to implement active-learning frameworks. According to current research, pedagogical reforms in reforming are not sustainable in disadvantaged communities unless they are accompanied by micro-level interventions that are specific to the community context (Akuma & Callaghan, 2018 [1,2] Sturrock et al., 2025) [20]. The shift in these entrenched pedagogical practices in Bihar, therefore, requires both to break structural institutional barriers and to create enduring, collaborative professional learning that responds to teachers' on-the-ground experiences and challenges (Benitez et al., 2026) [5].

Implications

The study has some implications to practice and policy. As for professional development, emphasis should be given to teaching methods that involve inquiry in science teaching, methods of questioning, experimentation using simple equipment, and interaction in the class that can be implemented in schools with limited infrastructure. Second, integrating technology should be a gradual process that requires teacher support, not just equipment for technology, as recent research indicates that technology is pedagogically useful only when connected with pedagogical content knowledge and inquiry-oriented planning.

Third, science teaching materials, such as lab equipment, must be functional for the implementation of activity-based science learning if schools are serious about implementing the activity-based approach. Fourth, administrative and non-teaching tasks must not be excessive and so planning for collaborative and/or investigative teaching must be feasible. Finally, school leaders and the local academic support systems should check the quality of instruction in addition to the extent of syllabus coverage, but also on student participation, quality of questioning and opportunities for scientific reasoning.

The paper highlights the importance of local observation in the classroom for research to understanding the actual practice. For future research, science learning environments in different districts could be compared, the student's voice could be incorporated, or the relations between teacher education, school leadership, and resource ecology could be explored in relation to science pedagogy in Indian secondary schools.

Limitations

The study was confined to 20 secondary schools with one science teacher per school, so the results are only applicable to these schools. The conclusions should therefore be understood in the context of these schools being just a sample of the schools in Bihar, and not necessarily of all secondary schools in India. Moreover, the original paper was descriptive and not inferential, and the revised paper is based on the quality and extent of reporting provided in the attached manuscript. Despite the above, the study is still worthwhile as it provides first-hand evidence from the classroom about science teaching in a realistic district setting. The local evidence is crucial because pedagogical reform is always abstract and implementation is always local.

Conclusion

The present paper confirms that science education in the sample secondary schools of Nalanda district was mostly teacher-centered, grounded in lecture methods, and still not very well equipped pedagogically and infrastructurally. The overall classroom culture was not conducive to inquiry-based, collaborative or technology-rich science teaching, although some teachers used local case studies and scaffolding to facilitate their teaching. Recent studies confirm the significance of these findings as teaching science based on inquiry and student-centered learning is found to have a positive effect on scientific creativity, understanding and engagement provided that the teacher receives adequate preparation, functional resources and enabling institutional conditions.

The paper thus signals to a larger educational issue. Policy alone does not enable curriculum aspirations for active and enquiry-based learning in science to be realised. They need continued investment in their teacher preparation, classroom materials, technology, and instructional leadership in the process of making reform ideas happen in regular science classes.

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