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Elementary Science Teaching: Actions, Dispositions, and Decisions That Shape Learning

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ABSTRACT

Instructional decision-making process is inherently complex, involving reasoning, choices, and dispositions that shape classroom practices. Science teachers' pedagogical actions and decisions are influenced by multiple factors, ranging from intrinsic beliefs to external constraints. This study explores the interplay of actions, dispositions, and decision-making in various teaching and learning strategies used in science classrooms. Using classroom observations and semi-structured interviews with 16 elementary science teachers from a nationwide mixed-methods study, we examine their instructional approaches. Findings indicate that most teachers rely on traditional methods, such as 'chalk-and-talk'

or text-based instruction, with their pedagogical strategies being predominantly discipline-oriented. Teachers' narratives reveal gaps in pedagogical knowledge, often leading to misconceptions or inadequate instructional dispositions. Drawing on situated cognition theory, we discuss how internal factors, including exam-driven teaching and workplace conditions, shape science instruction. Based on these findings, we propose recommendations to enhance science teaching practices.

Keywords: Classroom observation, Disposition, Pakistan, Pedagogical practices, Science education.

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INTRODUCTION

Research on the pedagogical quality of teachers highlights that their classroom practices are not shaped by knowledge alone but also by their dispositions, enduring tendencies that integrate beliefs, values, and affective orientations (Borko et al., 2007; Enderle et al., 2014; Wong & Luft, 2015). Dispositions can be understood as ‘abilities in motion’ that guide intelligent professional conduct (Dottin, 2009). They act as mediating mental representations that influence cognition and drive teachers’ instructional choices when activated (Hutner & Markman, 2016a). Thus, while teachers may hold professional knowledge and pedagogical skills, the presence or absence of relevant dispositions often determines whether these resources are enacted effectively in practice. This makes dispositions a central determinant of teaching quality, as they connect cognition with action. However, the process is complex, involving reasoning, decision-making, and alignment between teachers’ epistemological beliefs, their understanding of science, and their goals for instruction (Waters-Adams, 2006; Tiilikainen et al., 2019). Science teaching in particular demands that teachers balance competing instructional approaches, teacher-centered versus student-centered strategies, while navigating the contextual pressures of curriculum demands, assessment systems, and classroom realities.

Understanding teachers’ dispositions is therefore relevant in two ways: i) as a lens for explaining and interpreting teachers’ professional practices, and ii) as a foundation for improving science teaching and teacher education. At the level of

explanation, dispositions help ‘unlock the black box’ of how teachers make decisions in complex classroom environments (Korthagen, 2017; Webster-Wright, 2009). At the level of improvement, a deeper awareness of teachers’ personal dispositions, their “private curriculum” (Hamachek, 1999), offers insights into how teacher education can better bridge the gap between theoretical ideals and practical realities. Existing research has examined how teachers’ pedagogical choices vary across contexts and how these choices contribute to their professional development through social interaction and practice (Lave & Wenger, 1991; Thompson et al., 2018). Yet comparatively little is known about how science teachers’ dispositions operate in real classroom settings, how these dispositions influence their adoption of particular pedagogical strategies, and how they interact with contextual demands such as high-stakes assessment and resource constraints.

Against this backdrop, the present study investigates the dispositions that drive science teachers’ classroom practices through a situated cognition lens, attending to how teachers’ thinking and actions are shaped in interaction with classroom tools, routines, and sociocultural conditions (Putnam & Borko, 2000). We use Hutner and Markman’s (2016a) operationalization of science teacher beliefs as a complementary, goal-driven account of how dispositions and mental representations become activated and guide teachers’ in-the-moment instructional decisions. Accordingly, this paper addresses the following research question: What are the actions, dispositions, and decisions underlying various teaching and learning strategies used in science classrooms?

LITERATURE REVIEW

This study adopts the theoretical framework of situated cognition to examine science teachers’ dispositions, actions, and the reasoning behind their pedagogical choices. The focus is twofold: i) to understand teachers’ dispositions as a basis for explaining and interpreting classroom practice, and ii) to explore how insights into these dispositions can inform improvements in science teaching and teacher education. To achieve this, we draw on complementary models of teacher cognition, situated perspectives, and goal-driven approaches to explain how teachers’ dispositions shape and are shaped by practice.

Operational Definitions and Analytic Distinctions

In this study, we use dispositions as contextually activated tendencies that orient teachers toward particular ways of interpreting classroom situations and selecting instructional actions (i.e., “abilities in motion”). Analytically, dispositions are inferred when teachers’ talk signals a recurring evaluative orientation (e.g., valuing control, prioritising exam coverage, expecting quick correctness) that is linked to an action tendency (e.g., whole-class explanation, rapid self-answering, seating choices) across lessons and/or interviews. We

distinguish dispositions from related constructs as follows: knowledge refers to what teachers report knowing (e.g., strategies for group work; concepts such as SLOs; ways of using materials) and what is evidenced in practice; beliefs refer to teachers' stated propositions about teaching/learning (e.g., "students learn best when..."); goals refer to desired outcomes teachers pursue or avoid in a lesson (e.g., coverage, discipline, conceptual understanding), consistent with goal-driven accounts; and contextual constraints refer to enabling/limiting conditions (e.g., time, class size, resources, assessment pressures) that shape which goals and dispositions are more likely to be activated. In coding, segments were treated as knowledge gaps when teachers expressed uncertainty, incomplete understanding, or procedural absence (e.g., describing group work as seating only) without a clear evaluative stance; segments were treated as dispositional when teachers offered value-laden rationales or patterned preferences that consistently oriented decisions, even when alternative strategies were acknowledged.

Teachers Cognitive Process

Teachers' actions and decisions involve complex cognitive processes, which makes understanding teacher cognition essential for improving science instruction (Abell, 2007; Grossman, 1990; Hunter & Markman, 2015). Cognitive theorists (Markram, 2012; Markman & Dietrich, 2000; Reynolds et al., 1996) describe cognition as the activation of mental representations derived from prior learning and experiences, which are reinterpreted in light of external contexts.

Earlier research considered cognition largely independent of context, but more recent work highlights how teachers' thinking is shaped by social and environmental factors (Hunter & Markram, 2016b). Cognitive processes may also be limited by incomplete or inaccessible representations. Hunter and Markram (2016a) propose a dual-process model: subconscious activation of knowledge that remains inaccessible to awareness, and conscious, metacognitive processing where teachers deliberately reflect on their choices. Teachers may thus hold knowledge and skills that are not always accessible in the moment of practice. Furthermore, individual preferences and inclinations influence how teachers prioritise certain pedagogical considerations (Eitam & Higgins, 2010).

Situated Cognition in Science

Situated cognition offers a broader perspective by recognising that learning is embedded in sociocultural contexts and distributed across individuals, tools, and environments. As Putnam and Borko (2000) argue, cognition is (1) situated in physical and social contexts, (2) inherently social, and (3) distributed across participants and artefacts. This aligns with Dewey's concept of experiential learning, where authentic, collaborative engagement fosters meaningful and lasting teacher learning. Research in science education has widely applied situated cognition to explain how teachers develop professional competencies (Blanchard

et al., 2008; Buxton et al., 2013; Hennessy, 2006; Hutner & Markman, 2016b; Sadler, 2008). Teachers' dispositions—understood as integrated tendencies of knowledge, beliefs, and affect are central in this process. Dispositions influence whether teachers retain traditional beliefs or adopt new, student-centered practices (Altan et al., 2019).

Building on cognitive and situated perspectives, goal-driven models explain teachers' instructional practices as purposeful actions oriented toward achieving or avoiding specific outcomes (Hunter & Markman, 2017; Hutner et al., 2022a, b). Within this view, teaching is guided by both motivational systems and contextual representations, with classroom practices shaped by mediating factors such as knowledge, pedagogy, and beliefs, as well as environmental conditions (Aarts & Iliot, 2012). Hutner et al. (2022) identify three primary types of teacher goals: (1) habits of mind goals (e.g., developing students' critical thinking), (2) preparation for the future (e.g., equipping students for subsequent learning), and (3) science education goals (e.g., meeting curriculum standards). Teachers may also experience goal conflicts, such as balancing innovative instructional practices with exam requirements, which can be managed through strategies of goal balancing (Hutner et al., 2021).

Teachers' Actions, Disposition, Decisions, and Pedagogical Strategies

Understanding how dispositions interact with cognition and context helps explain teachers' pedagogical choices. These choices are often discussed in terms of teacher-centered (direct instruction) and student-centered (constructivist) approaches (Gage, 2009; Sato, 2014). In practice, however, classroom instruction frequently blends elements of both: teachers may combine explanation and demonstration with questioning, guided practice, and short collaborative tasks within the same lesson. Thus, the analytic distinction between 'passive' and 'active' learning is best understood as a continuum rather than mutually exclusive categories. While student-centered teaching is associated with increased engagement and motivation (Cairns & Arepattamannil, 2019; Liou, 2021), teacher-centered approaches may be selected to meet immediate curricular demands or to ensure coverage and performance on assessments (Huang & Cribbs, 2017; Lau & Lam, 2017).

Importantly, teachers' instructional strategies are not determined by dispositions alone; they emerge from the interaction of dispositions with contextual influences (e.g., institutional expectations, available resources, student characteristics, and language demands). In high-stakes testing environments, accountability pressures can cue teachers' performance-oriented goals and reinforce teacher-centered routines, even when teachers express positive orientations toward student-centered learning. Likewise, practical constraints such as large class sizes, limited instructional time, and uneven access to materials can narrow the range of feasible strategies and shape what teachers perceive as

‘workable’ in the moment. From a situated cognition perspective, these constraints are not merely background conditions; they form part of the setting in which teachers’ cognition is enacted and through which particular dispositions become more or less likely to be activated in practice (Putnam & Borko, 2000; Buxton et al., 2013; Borko et al., 1990).

RESEARCH METHOD

This paper is part of a larger study that examined the relationship between pedagogical practices and students’ performance in science and mathematics, while accounting for other relevant variables (Bhutta & Rizvi, 2022). The study adopted a mixed-methods design, incorporating two key components: i) a cross-sectional survey to assess teachers’ classroom practices and their students’ performance, and ii) qualitative interviews to gain an in-depth understanding of teachers’ dispositions and decision-making in relation to their teaching and learning strategies. This paper specifically focuses on the findings derived from the qualitative interviews, guided by the research question: What are the actions, dispositions, and decisions underlying various teaching and learning strategies used in science classrooms?

The qualitative data were collected from 16 elementary science teachers (grades 5, 6, and 8), randomly selected from a larger survey sample of 286 science teachers. Of the 16 participants, both female (n=10) and male (n=6) teachers were selected, representing a mix of public and private schools. A relatively higher number of teachers were interviewed from grade 5, followed by grades 6 and 8. Regarding academic qualifications, three teachers held a bachelor’s degree and were exclusively teaching grade 5, while the remaining 13 teachers, who had attained higher academic qualifications, were distributed across all three grades. The demographic data further revealed a mix of teachers with (n=11) and without (n=5) professional teaching qualifications. Notably, those without professional qualifications were predominantly teaching in private schools. In terms of teaching experience, only five teachers had been in the profession for more than 10 years, whereas the majority, except for one, had five years of experience or less.

The teachers’ classroom practices were initially assessed using a 3-point Classroom Observation Scale (COS). Each participating teacher was observed during one complete science lesson (approximately 30-40 minutes), and field notes were recorded to capture salient classroom routines and teacher–student interactions alongside COS ratings. Following the observation, a semi-structured interview was conducted to explore teachers’ actions, dispositions (as defined above), and pedagogical decisions underpinning the observed strategies. Interviews were audio-recorded with prior informed consent and conducted in either English or Urdu, depending on participants’ preference (most in Urdu). The data were analysed using thematic analysis; coding was conducted in the original

language of the interview to preserve meaning, and only the excerpts included in the manuscript were translated into English (Miles et al., 2014). To enhance trustworthiness, we maintained an audit trail of coding decisions and theme revisions, used iterative comparison across cases, and reviewed emerging interpretations against observation notes to check alignment between talk and practice.

Data Analysis

Interview recordings were transcribed verbatim. We conducted a thematic analysis to identify patterns in how teachers described their actions, dispositions, and pedagogical decisions. Analysis proceeded iteratively: (1) familiarisation with each transcript; (2) initial coding of meaning units in the language of the interview (primarily Urdu) to preserve participants’ intended meanings; (3) comparison of codes across transcripts to identify similarities and differences; (4) clustering related codes into candidate themes; (5) reviewing and refining themes against the full dataset to ensure internal coherence and clear distinction between themes; and (6) defining and naming themes and selecting illustrative excerpts (Miles et al., 2014). Situated cognition served as a sensitising framework during both coding and theme development by directing attention to how teachers’ talk linked (a) instructional goals and beliefs, (b) classroom routines and tools (e.g., textbook, board, seating), and (c) contextual constraints (e.g., assessment pressure, workload, resource availability) that shaped what teachers perceived as possible and appropriate in their settings. Only the excerpts used in the manuscript were translated into English after coding to minimise loss of meaning.

Table 1

Illustrative coding map linking themes to analytic constructs

Theme	Disposition indicators	Knowledge/ PCK indicators	Goals/context
Classroom arrangement	Preference for control; ability grouping as a management routine	Limited enactment knowledge of cooperative learning (roles, accountability, monitoring)	Goals: discipline, time-efficiency; Context: class size, resource scarcity
Planning with SLOs	Orientation toward coverage/recall; comfort with transmissive routines	Weak formulation/alignment of objectives, activities, and assessment	Goals: exam preparation, completing syllabus; Context:

			assessment pressures
Use of teaching materials	Orientation toward memorisation/reading accuracy over inquiry	Limited knowledge of how to use visuals/ videos interactively (pauses, prompts, tasks)	Goals: correct terminology, efficiency; Context: limited equipment/time
Teaching strategies (questioning, group work)	Rapid closure/answer-giving; prioritising correctness and pace	Limited repertoire for eliciting reasoning and scaffolding discussion	Goals: avoid silence/mistakes, maintain lesson flow; Context: mixed attainment, language demands

FINDINGS

This section presents findings from classroom observations and semi-structured interviews with the 16 elementary science teachers in this qualitative subsample.

An Overview of Observed Pedagogical Practices

Observation data revealed that the overall mean score for classroom practices among science teachers fell within the category of ‘moderate practices’ ($M = 1.52$, $SD = 0.34$) on a 3-point scale. Notably, more than half of the observed science lessons ($n = 9$; 56%) received a COS score below 1.5, indicating weak classroom practices. In contrast, only seven lessons (44%) achieved scores within the ‘moderate practices’ range (1.5-2.5).

Figure 1.

Classroom Observation Scale (COS) item-level mean scores for the observed lessons (3-point scale, where higher scores indicate stronger practice on the item).

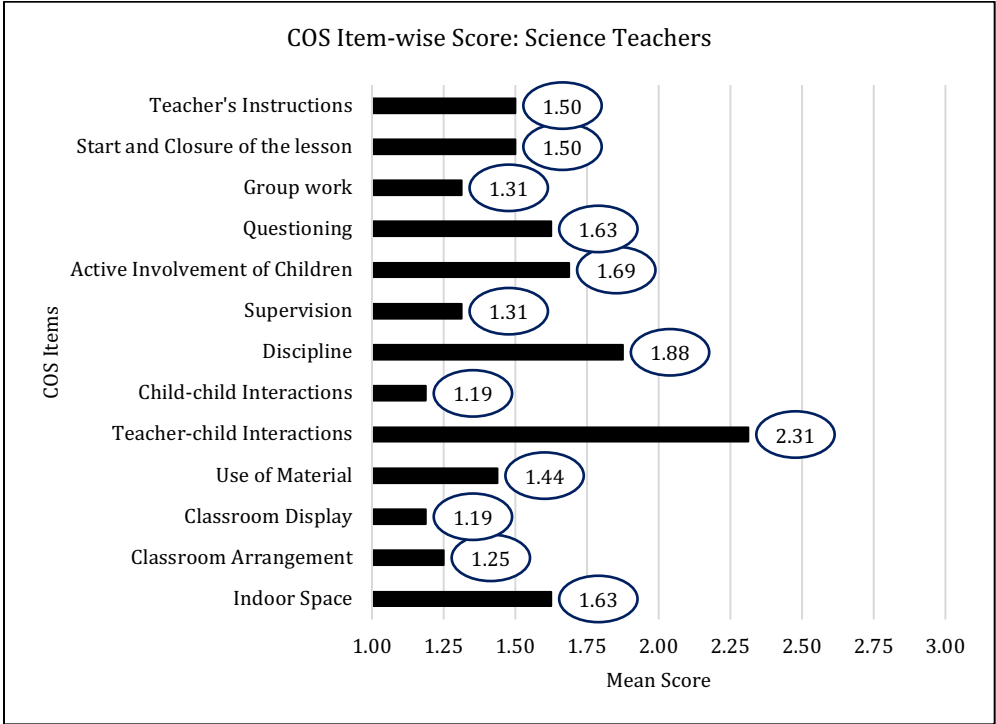


Figure 1 presents item-level COS scores, providing further insight into the teachers' actions and dispositions that influenced their pedagogical decisions. The relatively high score in teacher-child interaction suggests that teachers generally engaged with students in a supportive manner. Observations indicated that in some classrooms, teachers maintained a calm tone, treated students equitably, and attentively listened to their responses. Most teachers exercised adequate classroom control without resorting to harsh disciplinary techniques. However, there were a few instances where teachers employed progressive strategies, such as positively reinforcing students' behaviour through praise or encouragement.

In terms of active student involvement, effective engagement requires students to ask and answer questions, solve problems, and demonstrate creativity. While some classrooms met these criteria, many fell short. Classrooms were generally clean and provided adequate seating arrangements; however, most lacked sufficient space for indoor activities requiring physical movement.

Although some teachers made an effort to provide clear instructions, observations revealed that students often struggled to comprehend them.

A notably low score on the use of instructional materials suggests that most observed lessons relied on basic resources (e.g., blackboard, chalk, and textbooks) or occasionally incorporated supplementary materials (e.g., videos, charts). However, these materials were not consistently used in ways that increased student participation (e.g., guided observation prompts, discussion pauses, or follow-up tasks). Whole-class instruction remained the dominant approach in this subsample. Peer and group work were observed only in a few classrooms, and when implemented, often lacked core features of cooperative learning (e.g., clear roles, shared responsibility, structured instructions, and active monitoring). Another key concern was teacher supervision. Rarely did teachers provide constructive feedback to support students' skill development, acknowledge their efforts, clarify tasks, or ensure content accuracy. Furthermore, classroom displays were often absent or inappropriate for students' learning levels. Finally, opportunities for child-child interaction - which could foster peer learning - were seldom observed.

Teachers Explaining Their Actions and Dispositions Underlying Pedagogical Decisions

The thematic analysis of teacher interviews revealed key insights into their pedagogical decisions, classroom practices, and underlying dispositions. These findings are categorised into five overarching themes, each offering insights into how science teachers navigate instructional strategies, engage with students, and respond to contextual challenges.

Classroom Arrangement: A Tool for Asserting Teacher Authority

The findings indicate that classroom arrangement was primarily influenced by teachers' desire to maintain discipline and manage resources efficiently, rather than to facilitate collaborative learning. While the traditional seating arrangement, with the teacher at the front and students seated in rows, remained dominant, a few teachers deliberately arranged students into groups. However, their rationale was largely practical rather than pedagogical. As one teacher explained: "I arranged the students in groups of four members so that each group has access to sufficient available resources."

This reflects subconscious representation, where a teacher possesses pedagogical knowledge but remains unaware of its deeper implications for learning. Observations revealed that while students were seated in groups, they were often passive, merely staring at materials rather than engaging in meaningful interaction. This suggests that effective group work requires more than just rearranging seating; it demands clear instructions, active monitoring, constructive feedback, and sufficient learning resources to foster real collaboration.

Similarly, another teacher justified the use of a U-shaped classroom arrangement, stating: “In a U-shaped arrangement, the whiteboard is visible to everyone... students get both verbal and non-verbal communication from the teacher... and the teacher can easily observe all students.” This reinforces the dominance of teacher-centered instruction, where the teacher’s primary concern is control and visibility, rather than enhancing student interaction. While the teacher acknowledges the potential benefits of different seating arrangements, the focus remains on authority and surveillance, rather than leveraging these arrangements for interactive learning.

Interestingly, even in traditional classroom settings, subtle patterns in seating arrangements emerged. One practice involved placing students based on perceived ability, often judged through exam performance. A teacher described this approach: “The repeaters were mostly considered problematic and weak in terms of learning. Therefore, they were made to sit at the front of the class so that I [the teacher] could keep an eye on them.” In our analysis, this excerpt signals a deficit-oriented way of interpreting lower attainment that becomes embedded in a monitoring routine (front seating). While front seating can also be used as a supportive strategy, the teacher’s wording (“problematic and weak”) suggests that the practice may operate primarily as surveillance rather than as an instructional scaffold. We therefore interpret this as an instance where a management goal (keeping an eye on students) appears to outweigh goals related to inclusion and participation, with potential implications for how these students experience science learning.

Planning for Teaching: A Dichotomy Between SLOs and Practice

Student Learning Outcomes (SLOs) serve as an essential framework for lesson planning, ensuring that content, instructional strategies, resources, and assessment techniques are aligned. However, the findings suggest that while some teachers demonstrated basic awareness of SLOs, their understanding was often superficial or misaligned with the principles of engaged learning. One teacher, who exhibited a rudimentary grasp of SLOs, explained: “My target was to enable the students to know about the structure and functions of neurons.” Similarly, another teacher described her lesson objective, which involved providing students with a hands-on experience using magnifying glasses: “This is part of our SLOs - to show them [the students] the structure of monocot and dicot seeds... and which part of the seed grows into roots or shoots... we follow the SLOs.” While these teachers recognised the importance of setting SLOs, their focus remained at the lower levels of Bloom’s Taxonomy, centring around recall and observation rather than fostering critical thinking, inquiry, or deep engagement. The emphasis on showing and describing concepts resulted in teacher-centered instruction, rather than interactive or student-led learning experiences.

Conversely, most teachers demonstrated only a superficial familiarity with the term SLOs, often misinterpreting or loosely applying the concept. Many of their stated objectives were overly broad and content-heavy, as illustrated in the following statement: “The objective of my lesson was to enable students to understand how different systems of the body function and what the function of the excretory system is.” This overarching goal was too ambitious for a single 30- to 40-minute lesson, making it impractical and difficult to assess. In contrast, another teacher set an objective that was too narrow and lacked instructional depth: “My objective was to check the previous knowledge of the students.” Interestingly, classroom observations revealed that despite this stated goal, the teacher proceeded to introduce new content, revealing a misalignment between stated objectives and actual teaching practices.

These findings highlight several critical gaps in how science teachers conceptualise and implement SLOs: i) limited understanding of the pedagogical significance of lesson objectives beyond content delivery; ii) inappropriate formulation of SLOs - either too broad to be achievable or too narrow to be meaningful; iii) weak alignment between SLOs and instructional strategies, where teachers focus on knowledge transmission rather than active student engagement; and iv) lack of integration between SLOs and assessment techniques, making it difficult to measure whether learning outcomes are achieved effectively. These patterns reinforce the idea that for many teachers, knowledge transmission remains the dominant instructional goal, echoing Eitam and Higgins’ (2010) assertion that teachers tend to prioritise certain aspects of teaching while overlooking others. Consequently, while teachers may acknowledge the importance of SLOs, they struggle to translate them into meaningful, student-centered learning experiences.

Use of Teaching Material: A Quest to Maximise Students’ Learning

Findings from the COS revealed that the textbook and writing board are the most commonly used teaching materials in science classrooms across the country. However, despite their widespread availability, many teachers struggled to use even these basic resources effectively. For instance, the whiteboard was often underutilised for visual representation of concepts, such as drawing diagrams or models to support student understanding.

Instead, the textbook was predominantly used for reading instruction through the Grammar Translation Method, a strategy typically associated with language learning rather than science education. Under this method, teachers would read the science lesson aloud, have students take turns reading, and then translate difficult words into a more familiar language. The emphasis on rote reading rather than conceptual engagement suggests that teachers prioritised literal comprehension over scientific inquiry and critical thinking. One teacher rationalised this approach, explaining: “I read the lesson to them [students] and asked them to read turn by turn because, you know, how many difficult terms there are in science... If the

pronunciation of these words is not corrected at this stage, they would not be able to utter these words correctly in later stages of their education.” While the teacher’s concern for scientific vocabulary development is valid, the exclusive focus on reading fluency and pronunciation may come at the expense of students’ conceptual understanding. This misalignment between teaching methods and the nature of science education is reflected in students’ low performance on standardised science assessments (Bhutta & Rizvi, 2022; TIMSS, 2019).

A small number of teachers attempted to supplement textbook instruction with additional materials, such as charts, concrete objects, and videos. However, their usage often remained superficial and rote-based. For example, one teacher described using chart paper to reinforce key points: “The drill through the chart was the only effective way to help students remember the content better.” This response indicates a limited view of instructional materials - not as tools for conceptual exploration and engagement but rather as aids for memorisation. Similarly, another teacher provided students with low-cost materials (such as scissors and a stapler) to demonstrate types of levers in a hands-on activity. He explained: “My purpose of giving them concrete examples was to enable them to differentiate between three kinds of levers.” While this effort reflects an awareness of linking science to real-life experiences, the depth of engagement remains limited. The use of concrete materials was not necessarily accompanied by exploratory discussions, guided questioning, or problem-solving tasks, which are essential for active learning in science education.

Although resource constraints posed a challenge to technology integration, some teachers actively sought opportunities to incorporate digital tools. A few teachers were observed using multimedia, laptops, or mobile phones to play videos related to scientific concepts. For instance, one teacher attempted to enhance students’ understanding of photosynthesis by showing an animated video on her mobile phone to a class of 25 students. She justified her choice, stating: “Teaching the process of photosynthesis becomes easier using videos compared to diagrams because I can show tiny structures even inside the leaves through video.” When asked about her criteria for selecting the video, she elaborated: “I watched four different videos but selected this one because of its clear diagrammatic representations along with useful narratives... There were cartoon characters, and there was a better explanation of the concept [photosynthesis].” This response suggests that the teacher exercised deliberate selection based on visual clarity, content accuracy, and student engagement factors. However, the effectiveness of video-based instruction remained limited due to the lack of interactive elements. The entire video was shown without pauses for discussion, questioning, or student reflection, reducing its potential for active engagement.

Other teachers expressed various motivations for incorporating videos in science teaching, such as: “Videos help students learn with fun and interest.” “They improve students’ imagination power.” “They assist teachers in explaining

abstract and difficult concepts efficiently.” While these responses indicate a general awareness of the pedagogical benefits of videos, the effectiveness of such tools is contingent on their appropriate use. Simply playing a video without facilitating discussion, inquiry, and student engagement may lead to passive consumption of information rather than deep learning.

The findings highlight several fundamental issues in the way science teachers use instructional materials: i) over-reliance on textbooks for reading rather than conceptual engagement, leading to a disconnect between science teaching and inquiry-based learning; ii) limited use of visual aids and hands-on materials, with an emphasis on memorisation rather than conceptual exploration; iii) underutilisation of digital tools such as videos, where passive viewing is prioritised over interactive, discussion-driven learning; and iv) limited teacher training and awareness regarding how to effectively integrate teaching materials into lesson planning and delivery. These findings underscore the need for professional development that equips teachers with strategies to use teaching materials in ways that promote active learning, conceptual understanding, and scientific inquiry.

Teaching Strategies: Mere Activities or Active Involvement?

Effective science teaching requires a diverse range of teaching strategies to create an engaging learning environment that fosters active participation, collaboration, and higher-order thinking (Fauth et al., 2019). The following sections provide a critical analysis of teachers’ teaching strategies and their underlying dispositions.

Lesson Beginnings and Endings: Key Junctures in Learning: Observations revealed that some teachers attempted to recall the previous lesson at the start or summarise the current lesson at the end. However, in most cases, teachers began their instruction by directly announcing the topic or asking students to turn to a specific page. While a few teachers employed strategies such as posing questions to elicit students’ daily life experiences, their execution often lacked a meaningful connection to the lesson. For instance, in a lesson on microorganisms, a teacher asked students about their breakfast, reasoning that this approach would help establish a friendly classroom atmosphere. He explained: “At least this [asking the students about their breakfast] makes them feel that their teacher is their friend.”

Although fostering a welcoming classroom environment is important, the teacher missed an opportunity to link students’ responses to the lesson content. He neither made an explicit connection between breakfast and microorganisms (e.g., bacteria in food) nor guided students to understand the pedagogical purpose of the question. This highlights a missed chance to engage students meaningfully at a crucial stage of the lesson.

Whole-Class Teaching: A Predominant Strategy: Teachers largely relied on whole-class instruction, predominantly employing teacher-centered pedagogies. While a few teachers incorporated student engagement strategies, these efforts were often constrained. For example, during a lesson on the three states of matter, a teacher introduced a role-playing activity where students acted as particles to demonstrate intermolecular spaces. She reflected: “Students learn those things very quickly which are linked to their practical observations.” While this initiative provided a visual representation, it required careful execution to prevent misconceptions. The teacher focused on particle positioning but did not explicitly address particle movement, a critical aspect of the concept. Without precise scaffolding, students might develop an incomplete understanding, reinforcing the need for structured debriefing after such activities.

Similarly, in another instance, a teacher used a model of an eye to explain its structure. The effort was commendable, as it helped students visualise an abstract concept. She noted: “The students would learn better by practically dissecting various layers of the eye in the model, which was necessitated by a limited provision of material.” Despite these efforts, the dominant instructional mode remained ‘chalk-and-talk’ or textbook reading and translation, reinforcing passive learning rather than interactive engagement.

Group and Peer Work: A Lost Opportunity: Only a small fraction of teachers incorporated group work, and when they did, its implementation was often ineffective. In one instance, a teacher distributed one seed per pair for students to observe, yet she proceeded to explain its structure herself, rather than encouraging student-led discovery. When asked about her rationale, she stated: “Pair work is easy to handle... I would need only one seed for each pair.” Her response suggests a limited understanding of group work’s pedagogical benefits, viewing it primarily as a resource management strategy rather than a means for active learning.

In another classroom, students were seated in groups but worked individually or in pairs. The teacher explained: “If they [students] are in groups, it is easier for them to ask their friends when they face difficulties in reading certain words from the textbook.” While peer assistance in reading can be beneficial, this practice did not leverage the full potential of collaborative learning. Similarly, another teacher formed mixed-ability groups to support struggling students but undermined this approach by directing questions exclusively to high-achieving students: “I asked questions from group leaders with the intention that these students would be able to respond appropriately because they were made leaders based on their good performance.” By privileging certain students, this approach inadvertently reinforced hierarchical participation, limiting equal engagement and shared learning opportunities.

Questioning as a Tool for Teaching and Assessment: While questioning was a prevalent strategy, its implementation varied significantly in quality. Teachers primarily used questions for three purposes: i) assessing students' prior knowledge; ii) evaluating students' understanding during or after the lesson; iii) stimulating discussion. One teacher described her approach: "I asked them [students] questions from the last lesson in order to check their understanding. When they respond correctly, I introduce the new lesson... otherwise, I have to revise the previous lesson." This approach, however, prioritised content reproduction over conceptual linkage. Instead of using prior knowledge to scaffold new learning, teachers often focus on factual recall (e.g., "What is an atom?") rather than fostering deeper inquiry (e.g., "Why do atoms behave differently in different states of matter?").

Similarly, teachers frequently employed questioning to confirm comprehension before progressing in the lesson. One explained: "I was asking questions because I needed to make sure that if students were clear on one point, then I would move to the next one, otherwise I would not." While this approach indicates responsiveness to student understanding, the questioning pattern primarily targeted factual recall rather than higher-order thinking. Encouragingly, a small subset of teachers attempted to pose open-ended questions to generate discussion: "Providing students opportunities for relating science lessons with daily life can stimulate their thinking."

However, questioning patterns varied, with some teachers engaging students in peer responses, while others resorted to self-answering: "If a child is unable to respond to my question, I encourage other students to answer... this might help them understand the answer better from their peers." This peer-supported approach has merit but requires careful teacher facilitation to ensure accuracy and depth in student responses. Conversely, another teacher justified self-answering: "When the students do not know [the answer], it is important to tell them... I think if a particular student does not know the answer, others may also not know." This disposition reflects a tendency toward direct instruction rather than fostering student agency in knowledge construction. Furthermore, while some teachers encouraged students to ask questions, these were rarely used as opportunities to extend learning.

To sum up, teaching strategies applied across the country, the analysis highlights a critical gap between teachers' intentions and their instructional execution. While some attempted active learning strategies, these were often applied superficially or without a clear pedagogical foundation. The reliance on whole-class instruction, ineffective group work, and questioning practices that prioritise recall over inquiry suggests the need for targeted professional development. To enhance student engagement and learning outcomes, teachers should: i) use lesson openings to connect prior knowledge with new concepts meaningfully; ii) plan whole-class activities that go beyond mere demonstrations

and integrate conceptual discussions; iii) implement group work that fosters shared inquiry rather than just resource sharing; iv) employ questioning techniques that promote higher-order thinking and scaffold deeper discussions. By shifting from passive to active learning strategies, science education can become a dynamic process that truly enhances students' understanding and curiosity.

DISCUSSION

The findings provide insight into the rationale behind the pedagogical strategies employed by science teachers. These findings extend previous research, which has largely focused on distinguishing between effective and ineffective teaching practices. Drawing from the theoretical framework, this study confirms the presence of limited pedagogical knowledge among teachers, which is evident in their dispositions and instructional decisions. Recent work continues to show that science teachers' pedagogical knowledge remains fragmented and often underdeveloped, even when supported by structured professional tools (Hartmuth et al., 2025). Due to this limitation, teachers often rationalise their pedagogical choices without clear pedagogical intent or meaningful learning outcomes. This aligns with emerging evidence that teachers frequently rely on habitual or intuitive decisions rather than deliberate pedagogical reasoning, even when frameworks exist to guide reflective practice (Chaitidou & Peikos, 2026).

According to Gess-Newsome et al. (2019), high-quality teaching necessitates purposeful and deliberate instructional planning that results in a coherent learning experience for students. However, our findings indicate that teachers' decisions, such as adopting different classroom arrangements, were often driven by disciplinary concerns rather than pedagogical goals. Similar patterns have been documented in recent studies showing that teachers' enactment is shaped more by contextual pressures than by pedagogical intent (Hartmuth et al., 2025). Likewise, labelling students was perceived as a behavioural management strategy, with little awareness of its long-term consequences on student learning and self-perception. These findings underscore that limited pedagogical knowledge can lead to inadequate instructional dispositions. Cognitive representations of teaching science appear to be activated only at an epistemological level, yet they remain disconnected from pedagogical practice, leading teachers to default to direct instructional approaches (Waters-Adams, 2006). Contemporary research reinforces this disconnect, noting that teachers often struggle to translate conceptual knowledge into enacted practice without explicit scaffolding (Chaitidou & Peikos, 2026).

From a situated cognition perspective, the findings further suggest that sociocultural factors, such as school policies, reinforce rigid, teacher-dominated practices. Teachers' assumptions about effective teaching are deeply rooted in maintaining discipline, which they believe will maximise learning. However, these

assumptions may reduce content knowledge to mere factual transmission, limiting engagement with higher-order cognitive skills as outlined in Bloom's taxonomy. This supports the argument that teachers' pedagogical limitations prevent them from adopting innovative instructional practices that could challenge their pre-existing attitudes and beliefs (Gess-Newsome et al., 2019).

Furthermore, the study found that science teachers often lacked clear conceptions of learning outcomes and relied predominantly on basic instructional materials, such as textbooks and the board. In some instances, teachers displayed a subconscious reliance on routine instructional decisions, failing to consciously engage with pedagogical reasoning. Strikingly, some teachers deviated from science-specific teaching goals and instead prioritised developing reading skills, an approach more relevant to language instruction. While teachers expressed awareness of the value of student-centered pedagogies, this knowledge did not always translate into practice. This aligns with Gess-Newsome's (2015) assertion that possessing pedagogical knowledge does not necessarily lead to its implementation. Hutner and Markram (2016) further argue that without a specific instructional goal, teachers may recognise the value of an approach but fail to engage with it in practice. For instance, the misplaced emphasis on 'developing reading skills' in a science classroom inhibits the activation of inquiry-based teaching methods.

While the study has explored teachers' underlying pedagogical thinking, it is equally important to consider the contextual factors that restrict them from implementing student-centered approaches. Social cognition theory suggests that teachers' instructional thinking is shaped by their physical and social environment. Extensive research has highlighted contextual constraints that hinder effective science teaching (Adu-Boateng & Goodnough, 2022; Davis et al., 2006; Mikeska et al., 2017; Thibaut et al., 2018). Based on our findings, we categorise these constraints into two key domains: i) internal context - this includes direct challenges within the classroom setting, such as heavy workloads, resource limitations, exam-oriented teaching, and restrictive working conditions that limit pedagogical flexibility; and ii) external context - this encompasses broader sociocultural and institutional factors, such as language policies, parental support, students' socioeconomic backgrounds, and absenteeism, all of which pose indirect yet significant challenges to instructional approaches (Bhutta & Rizvi, 2022).

While internal constraints largely affect formal classroom activities, external factors operate beyond the immediate school environment, influencing teacher decision-making at a systemic level. Further empirical exploration of these external influences is necessary to understand their impact on teachers' pedagogical approaches and dispositions. This understanding is crucial for informing teacher education programmes, particularly in the Global South, where these contextual barriers are more pronounced.

CONCLUSION

This study has critically examined the pedagogical practices of science teachers, uncovering the cognitive and contextual factors that shape their instructional choices. The findings suggest that limited pedagogical knowledge, coupled with restrictive sociocultural contexts, significantly influences teachers' approaches to science instruction. While teachers acknowledge the importance of student-centered learning, their practices largely remain teacher-directed, often prioritising discipline and control over meaningful pedagogical engagement.

The analysis underscores the need for professional development initiatives that go beyond basic pedagogical training to actively challenge entrenched dispositions and instructional habits. Furthermore, addressing systemic barriers - such as excessive workload, limited resources, and rigid institutional structures - is essential for fostering an environment conducive to effective science teaching.

Improving science education requires a multifaceted approach that integrates teacher education, school-level support, and broader policy interventions. By addressing these interrelated factors, we can move towards a more effective and engaging science education framework, one that promotes critical thinking, inquiry-based learning, and meaningful student participation. Based on the findings, this study proposes the following recommendations to enhance science teaching:

Enhancing Pedagogical Knowledge and Addressing Dispositional Barriers: Teachers' limited pedagogical knowledge leads to inadequate instructional practices and misconceptions about effective teaching. One possible explanation is that teachers tend to rely on their past experiences and beliefs, often formed during their own schooling. To counter this, teacher education programmes must focus on fostering reflective practices that encourage teachers to critically evaluate and adapt their instructional strategies. Creating communities of practice, where teachers collaboratively explore and implement research-based pedagogies, can help bridge this knowledge gap (Ansari & Asad, 2024).

Goal-Driven Teacher Preparation: Teacher education should emphasise the importance of clear, subject-specific instructional goals. Our findings indicate that teachers' goals are often inconsistent and misaligned with the objectives of science education, sometimes prioritising literacy skills over scientific inquiry. By ensuring that teachers develop a strong sense of purpose in their instructional approaches, professional development programmes can enhance their motivation and effectiveness, ultimately leading to higher-quality teaching.

Addressing the Influence of Socioeconomic and Cultural Factors: External factors such as parental support, students' socioeconomic background, and the medium of instruction can shape teachers' expectations and instructional choices. For instance, teachers who perceive a lack of parental involvement may

unconsciously lower their expectations for students from disadvantaged backgrounds. Acknowledging and addressing these biases through teacher training can help ensure that all students receive equitable learning opportunities.

Further Research on Teacher Cognition and Contextual Challenges: There is a pressing need for more research on the interplay between teachers' thinking, instructional actions, and dispositions, particularly in developing countries where sociocultural and systemic challenges differ significantly from those in developed contexts. Future studies should explore cognitive models of teaching and decision-making within these settings to develop tailored interventions that support teachers in overcoming contextual barriers.

By implementing these recommendations, policymakers, educators, and researchers can work collaboratively to transform science education, ensuring that teachers are equipped with the knowledge, skills, and support necessary to foster a dynamic and engaging learning environment.

DECLARATIONS

Conflict of Interest

The authors declare that there are no conflicts of interest associated with this study. Research data can be provided upon reasonable request.

Use of GenAI

Artificial intelligence tool (ChatGPT) was consulted solely for language checking. The article was originally written in mid-2022, before the widespread availability of generative AI tools.

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