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Structure without Authoritarianism: School Discipline as a Condition for Inquiry-Based Science Learning in Primary Education

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Abstract
Inquiry-based science education is commonly associated with autonomy, exploration, and student voice, whereas school discipline is often associated with compliance and teacher control. This conceptual opposition obscures the regulatory conditions under which primary pupils can inquire safely, equitably, and productively. Drawing on research in inquiry learning, classroom structure, scientific argumentation, dialogic teaching, and self-regulation, this integrative review argues that inquiry requires discipline but not authoritarianism. Discipline is reconceptualised as the purposeful coordination of material activity, time, participation, evidence, and responsibility. The article proposes an Inquiry Discipline Framework comprising five interdependent domains: material and safety discipline; procedural and temporal discipline; collaborative and dialogic discipline; epistemic discipline; and self-regulatory discipline. It then maps these domains onto the phases of orientation, conceptualisation, investigation, conclusion, discussion, and reflection. The analysis distinguishes transparent, purpose-bound structure from controlling practice and explains how regulation can move from teacher direction through co-regulation towards pupil self-regulation. Primary science examples demonstrate how non-negotiable safety boundaries can coexist with consequential pupil choice in experimental design, representation, and explanation. The framework also highlights equity, language, and access to epistemic roles as central disciplinary concerns. Implications are developed for lesson planning, assessment, teacher education, curriculum implementation, and research. The article concludes that the relevant alternative to authoritarian discipline is not permissiveness but structured participation: boundaries are educationally legitimate when they protect inquiry and expand pupils' capacity to undertake its intellectual work.

Keywords: Inquiry-Based Science Education, Classroom Structure, School Discipline, Primary Education, Self-Regulation

1. Introduction

Inquiry-based science education is often described through the language of curiosity, agency, exploration, and student voice. These commitments are important, particularly in primary education, where children's questions can become powerful resources for learning. Yet the rhetoric of freedom can conceal a practical truth: inquiry is not educationally productive simply because pupils are active. A classroom in which children handle equipment, exchange ideas, record observations, and revise explanations is a highly organised social and intellectual environment. It requires more—not less—attention to rules, roles, timing, evidence, and responsibility. The central claim of this article is therefore that school discipline, when understood as purposeful structure rather than authoritarian control, is a condition for inquiry-based science learning.

This claim addresses a persistent false choice. One side associates discipline with silence, compliance, and teacher domination; the other associates inquiry with unrestricted choice and minimal intervention. Neither position describes strong primary science teaching. Authoritarian control may produce visible order while suppressing questions, risk taking, disagreement, and the public revision of ideas. Permissive inquiry, by contrast, may produce activity without sustained reasoning, inequitable participation, or reliable attention to safety and evidence. Productive inquiry occupies a third position: the teacher establishes a bounded environment in which pupils can exercise meaningful epistemic agency.

The distinction matters because primary pupils are novice participants in scientific practices [1, 2]. They do not enter school already knowing how to share scarce materials, vary one factor at a time, maintain a record, distinguish observation from inference, challenge a claim respectfully, or persist when evidence is ambiguous. These practices must be taught, modelled, rehearsed, and gradually transferred to pupils. Research on inquiry consistently shows that guidance supports learning and performance, whereas minimally guided activity can overload novices or allow superficial strategies to persist [3-5]. Recent reviews likewise identify classroom management, teacher support, and the orchestration of practical work as recurring challenges in open inquiry [6, 7].

Discipline in this article refers to the norms and regulatory arrangements that make shared scientific work possible. It includes the safe handling of materials, the sequencing of an investigation, the allocation of turns and responsibilities, the public accountability of claims to evidence, and pupils' increasing capacity to monitor their own conduct and learning. Such discipline is preventive, explanatory, and educative. Its purpose is not to secure obedience for its own sake but to protect persons, time, resources, participation, and the integrity of inquiry.

The article develops an integrative conceptual review organised around three questions: What forms of discipline are inherent in inquiry-based primary science? How can teachers provide structure without suppressing autonomy and dialogue? How can regulation be transferred from teacher to pupils across an inquiry cycle? In response, it proposes an Inquiry Discipline Framework (IDF) with five interdependent domains: material and safety discipline; procedural and temporal discipline; collaborative and dialogic discipline; epistemic discipline; and self-regulatory discipline.

The distinctive contribution of the IDF lies in bringing together dimensions that have generally been examined separately. Research on guided inquiry has primarily addressed the degree and effects of teacher guidance; autonomy-supportive teaching has focused on the motivational quality of teacher–pupil interaction; productive disciplinary engagement has examined the relationship between pupil authority and accountability; and self-regulation research has investigated learners' developing capacity to plan, monitor, and evaluate their learning. The IDF integrates these perspectives within the concrete material, social, temporal, and epistemic demands of primary science inquiry. It therefore offers a domain-specific account of what must be regulated, why particular forms of structure are educationally legitimate, and how responsibility can be progressively transferred to pupils. In this way, the framework connects classroom management with the distinctive demands of learning science and provides a basis for teaching, teacher education, and empirical research.

2. Review Design and Conceptual Scope

The article uses an integrative review design. Integrative reviews are appropriate when a problem crosses established research traditions and when the goal is not only to aggregate effects but also to clarify concepts and construct a usable synthesis [8, 9]. Here, relevant knowledge is distributed across inquiry-based science education, classroom management, self-regulated learning, dialogic teaching, scientific argumentation, and motivational research. A narrowly bounded effectiveness review would not adequately explain how these literatures converge on the problem of disciplinary structure.

Literature was identified through targeted searches of Scopus, Web of Science, ERIC, and Google Scholar, supplemented by backward searching of the reference lists of particularly relevant reviews and conceptual publications. Searches combined terms concerning primary or elementary science with terms such as inquiry learning, guided inquiry, classroom management, practical work, teacher guidance, scaffolding, scientific practices, argumentation, epistemic agency, autonomy support, and self-regulation. No fixed starting date was imposed because the conceptual synthesis required the inclusion of foundational contributions, although priority was given to recent peer-reviewed research available at the time of manuscript preparation. Sources were included when they directly informed the material, procedural, collaborative, epistemic, or self-regulatory conditions of inquiry in primary or school science. Systematic reviews, meta-analyses, major conceptual contributions, and empirical studies with clear relevance to these conditions were prioritised. Seminal works were retained where they established concepts—such as inquiry phases, productive disciplinary engagement, practical epistemology, or self-regulation—that remain necessary for interpreting recent evidence. The search was intended to support conceptual integration rather than exhaustive identification or quantitative aggregation of all eligible studies.

The synthesis was conducted in three stages. First, the literature was read for recurring conditions under which inquiry succeeds or fails: guidance, cognitive demand, material organisation, safety, talk, accountability, and pupil regulation. Second, these conditions were compared with distinctions from classroom-management and motivation research, especially the distinction between structure and control. Third, the resulting categories were tested against the phases of an inquiry cycle and against typical primary science activities. The five IDF domains emerged as analytically distinct but practically interdependent forms of regulation.

This is a conceptual review rather than a systematic review claiming exhaustive coverage. It does not estimate a pooled effect or rank particular programmes. Its contribution is explanatory: it identifies why discipline is intrinsic to inquiry, distinguishes productive structure from authoritarian control, and proposes observable indicators that can guide research and practice. The argument is primarily directed to primary education, although several principles may apply to later phases of schooling.

3. Inquiry is a Disciplined Practice

Scientific inquiry is sometimes reduced to a sequence of hands-on activities. However, manipulating objects is not equivalent to investigating a question, and observing a result is not equivalent to constructing an evidence-based explanation. Experimental activity becomes inquiry only when it is organised around meaningful questions, systematic evidence, reasoned explanation, and reflection [10]. Inquiry therefore involves coordinated movement among questions, prior ideas, procedures, data, representations, claims, and critique [11]. Pedaste *et al.* [12] synthesised inquiry models into five broad phases, orientation, conceptualisation, investigation, conclusion, and discussion, with reflection and communication operating across them. Each phase creates specific regulatory demands. Pupils must know what is open to decision, what is constrained, what counts as progress, and how their actions relate to the question under investigation.

This account makes discipline epistemically relevant. A rule such as 'change one factor and keep the others the same' is not merely a behavioural direction; it protects the interpretability of evidence. A requirement to label measurements, preserve anomalous results, or distinguish what was seen from what is inferred is not administrative tidiness; it sustains the warrant for a claim. Similarly, listening to another group's explanation is not simply politeness. It enables comparison, critique, and the revision of ideas. Classroom norms are therefore woven into the production of knowledge.

Ford [13] describes science learning in terms of disciplinary authority and accountability. Learners need opportunities to construct and defend knowledge claims, but their authority is not unlimited: claims remain accountable to evidence and to shared disciplinary norms. Sandoval [14] similarly shows that pupils develop practical epistemologies—working assumptions about what counts as knowledge and how it is produced—through the design of inquiry tasks. If the teacher values completion more than explanation, pupils may learn that school science means obtaining the expected answer. If procedures and talk make reasoning visible, they can instead learn that scientific knowledge is revisable, evidence-based, and publicly accountable.

Inquiry also redistributes authority. Pupils may decide how to represent results, which pattern deserves attention, or whether available evidence supports a conclusion. Yet transferring such decisions does not require the teacher to withdraw. Productive disciplinary engagement depends on problematisation, student authority, accountability to others and to disciplinary norms, and sufficient resources [15]. These principles are mutually dependent. Authority without accountability can become arbitrary choice; accountability without authority becomes recitation; problems without resources create frustration rather than inquiry.

At primary level, the social and material complexity is especially visible. A group investigating electrical circuits must coordinate access to cells, wires, and bulbs; avoid unsafe connections; agree how to test a claim; record unsuccessful configurations; and explain why a circuit works. The teacher may allow multiple designs while holding firm boundaries around safety and evidence. What appears as classroom discipline is simultaneously the infrastructure of scientific thinking.

The practical conclusion is that inquiry cannot be defined by the absence of teacher direction. Forms of inquiry vary in who poses the question, selects procedures, interprets evidence, and communicates conclusions. Guided inquiry can preserve consequential pupil choices while supplying the structure that novices need. Across large-scale and experimental research, guided forms tend to be more productive than unguided discovery, particularly when guidance targets the process pupils are not yet able to regulate independently [16-20].

4. Structure without Authoritarianism

Structure and autonomy are frequently treated as opposites, but motivational theory and classroom research suggest a different relationship. Structure communicates goals, pathways, boundaries, and informative feedback; control pressures pupils to think or act in prescribed ways through threats, guilt, surveillance, or rewards that displace the purpose of learning. Autonomy support acknowledges pupils' perspectives, provides meaningful choices, explains necessary constraints, and invites initiative. Strong teaching can therefore be both highly structured and autonomy supportive [21, 22].

In inquiry science, the difference is apparent in how a teacher uses authority. An authoritarian teacher may demand a predetermined conclusion, interrupt alternative explanations, assign roles without rationale, and treat procedural deviation as defiance. A structured but non-authoritarian teacher makes safety boundaries explicit, explains the scientific reason for controlling variables, provides role options, and asks groups to justify departures from an initial plan. The second classroom is not less demanding. It is more demanding because compliance is replaced by reasoned responsibility.

The relevant question is not whether the teacher controls the lesson, but what is controlled, why, and for how long. Some constraints are non-negotiable because they protect safety, dignity, or scientific validity. Others are temporary scaffolds that should fade with competence. Still others should be open to pupil decision from the beginning. A teacher might prescribe the available materials and time, co-construct criteria for a fair test, and allow groups to choose a representation and defend a conclusion. This layered distribution of control creates genuine agency within a coherent task.

Authoritarianism can also be quiet and epistemic. When every question has already been answered in the teacher's mind, a lesson may look orderly and practical while pupils merely reproduce an algorithm. Verification activities can have legitimate purposes, especially for learning equipment or establishing a common phenomenon, but they should not be mislabelled as open inquiry. The problem is not teacher knowledge or direction; it is the foreclosure of intellectual work that pupils are capable of undertaking.

Conversely, permissiveness can conceal unequal control among pupils. In an apparently open group task, a confident pupil may monopolise equipment, a fluent speaker may define the conclusion, and quieter classmates may become assistants. Without norms for turns, roles, evidence, and disagreement, freedom is distributed according to status rather than educational purpose. Structured participation is therefore an equity measure as well as a management strategy.

Table 1 distinguishes three regulatory patterns. These are ideal types rather than fixed teacher identities; the same lesson may move among them. The analytic value lies in locating the purpose of boundaries and the quality of pupil agency. Disciplined inquiry is characterised by transparent constraints, contestable ideas, shared responsibility, and regulation that is progressively transferred rather than permanently retained.

Table 1: Three regulatory patterns in inquiry-based science

Dimension	Authoritarian control	Permissive activity	Disciplined inquiry
Primary purpose	Secure obedience and visible order	Maximise choice and activity	Enable safe, equitable, evidence-responsive inquiry
Teacher authority	Personal, unilateral, difficult to question	Withheld even when support is needed	Purpose-bound, explained, proportionate, and revisable
Pupil agency	Limited to following directions	Choice without adequate criteria or support	Consequential choice within intelligible boundaries
Treatment of ideas	Expected answer is protected	All ideas treated as equally adequate	Ideas are open; claims are accountable to evidence
Group participation	Teacher assigns and monitors compliance	Informal participation may reproduce status	Roles and talk norms distribute epistemic work
Response to error	Correction, sanction, or concealment	Error noticed but not necessarily examined	Error and anomalous data become resources for revision
Long-term outcome	Dependence on external control	Fragmented habits and unequal agency	Growing competence, responsibility, and self-regulation

Note. Ideal types developed for this review. Their purpose is diagnostic rather than classificatory.

5. The Inquiry Discipline Framework

The proposed Inquiry Discipline Framework identifies five domains that jointly support productive inquiry. The domains are not a checklist of generic classroom rules. Each names a type of regulation required because of the material, social, and epistemic character of science learning. Weakness in any one domain can distort the entire inquiry. A safe and orderly activity can remain intellectually empty; a sophisticated discussion can remain exclusionary; a well-designed investigation can produce uninterpretable evidence if records are incomplete.

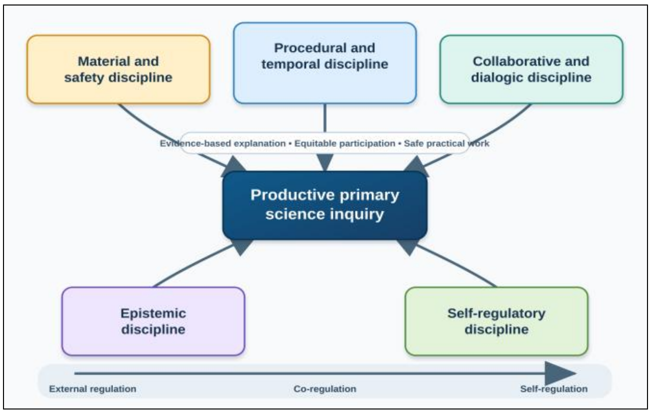
Material and safety discipline concerns the responsible use, distribution, and care of equipment and substances. Primary classrooms often contain many groups working simultaneously with limited resources. Routines for collecting trays, checking components, carrying liquids, responding to spills, and returning materials protect pupils and reduce transition time. The educational goal is not risk elimination but competent participation in managed risk. Pupils should increasingly understand the reasons for safety norms and learn to anticipate hazards rather than wait for correction.

Procedural and temporal discipline concerns how an investigation unfolds. It includes attending to the question, planning a fair comparison, following or revising a sequence, recording decisions, and using time purposefully. Primary pupils often experience difficulty coordinating several demands at once. Visual phase cards, short planning templates, stopping points, and teacher check-ins can externalise the process. Such supports should make the logic of inquiry visible rather than reduce it to a recipe. A procedure becomes educative when pupils can explain what each step contributes to the question.

Collaborative and dialogic discipline concerns equitable access to action and talk. Inquiry groups require norms for sharing equipment, seeking clarification, disagreeing with ideas rather than persons, and making collective decisions. Mercer *et al.* [23] demonstrated that explicitly teaching ground rules for exploratory talk can help children reason together in science. Collaborative discipline is not achieved merely by seating pupils in groups. It requires accountable participation structures and teacher attention to status, language, and the distribution of consequential roles.

Epistemic discipline concerns the standards by which knowledge claims are produced and evaluated. Pupils learn to separate observation from inference, connect claims with relevant data, consider alternative explanations, represent patterns, and revise a conclusion when evidence changes. These practices connect epistemology with pedagogy by positioning inquiry as participation in the production, evaluation, communication, and revision of scientific knowledge [24]. Modelling and representation can make these epistemic decisions accessible to learners [25]. Argumentation is central because scientific understanding develops through collaborative critical discourse [26]. Epistemic discipline protects inquiry from becoming opinion exchange: all pupils may contribute, but no claim is exempt from the question, «What makes you think that?’

Self-regulatory discipline concerns pupils’ growing capacity to plan, monitor, and evaluate their participation and learning. It includes noticing distraction, checking progress against a question, seeking help strategically, persisting through uncertainty, and evaluating the quality of a group’s evidence. Self-regulation does not arise from repeated external control. It develops when teachers model regulatory thinking, share responsibility, provide feedback, and create opportunities for reflection [27, 28]. In this developmental sense, discipline is successful when pupils need less direct regulation because they have appropriated its purposes.



Note: Author-generated conceptual synthesis based on the reviewed literature. The five domains converge on productive inquiry; regulation shifts adaptively from external regulation to co-regulation and self-regulation.

Fig 1: The Inquiry Discipline Framework and the developmental transfer of regulation

Fig 1 represents the domains as converging on productive inquiry and places them above a developmental continuum from external regulation through co-regulation to self-regulation. The continuum does not imply a uniform or linear withdrawal of the teacher. Regulation may move in both directions and may differ across domains within the same lesson. For example, pupils may regulate turn-taking and collaborative discussion independently while still requiring direct teacher guidance when using unfamiliar equipment or addressing a significant safety risk. A new material, safety concern, or conceptually demanding task can therefore justify renewed modelling and guidance even when pupils demonstrate independence in other aspects of the inquiry. The goal is adaptive transfer, not teacher absence.

The five domains also clarify why behaviour cannot be separated from curriculum. A pupil who leaves a group task may be avoiding conceptual uncertainty, exclusion by peers, a language demand, or confusion about the procedure. Treating the behaviour only as rule breaking can miss the instructional cause. The IDF directs attention to the function of structure: which domain is failing, what participation is being obstructed, and what scaffold could restore productive agency.

6. Regulation Across the Inquiry Cycle

The amount and form of structure should change across an inquiry cycle. During orientation, the teacher creates shared attention and makes the phenomenon accessible while protecting room for wonder. A brief demonstration, discrepant event, or familiar problem can focus the class. Discipline at this stage concerns listening, observing closely, and withholding premature closure. If the teacher immediately supplies the scientific explanation, curiosity is converted into recall; if the phenomenon is poorly bounded, pupils may generate questions too broad to investigate.

During conceptualisation, pupils turn curiosity into investigable questions and tentative explanations. The teacher can distinguish questions that can be answered with available time and materials from those requiring other methods. Sentence stems and examples may support younger pupils, but selecting the wording for them removes an important epistemic decision. Co-constructed criteria—clear variables, observable outcomes, feasible scope—make boundaries intelligible and allow pupils to evaluate their own questions.

During investigation, material, procedural, and collaborative demands peak. The teacher may use prepared equipment trays, role rotations, visual safety cues, and short checkpoints. On-the-fly scaffolding is crucial because planned guidance cannot anticipate every difficulty. Evidence from primary inquiry indicates that teachers support participation by focusing attention, prompting explanation, and problematising pupils' actions in response to emerging needs [29]. Effective intervention is diagnostic: it supplies enough support to restart thinking without taking over the decision that constitutes the learning opportunity.

During conclusion, pupils must move from collected information to a warranted claim. Many groups report what happened but do not explain how the evidence answers the original question. Claim–evidence–reasoning prompts, annotated graphs, or comparison matrices can support this transition. The teacher's discipline is epistemic: asking whether all data have been considered, whether a result is being ignored, and whether the strength of language matches the strength of evidence. Different conclusions may remain legitimate when data are limited, provided that pupils make their warrants explicit.

During discussion, regulation concerns public reasoning. A whole-class conversation requires norms that permit disagreement without humiliation and ensure that authority does not default to the quickest speaker or to the teacher. The teacher can sequence contrasting group findings, ask pupils to revoice one another, and delay evaluation while evidence is compared. Scientific argumentation becomes educational when critique is normalised as care for the quality of an idea rather than as conflict between persons [26, 30].

Reflection runs through every phase. Brief prompts—What decision did we make? What evidence changed our plan? Who has not yet handled the equipment?—turn regulation into an object of learning. Table 2 summarises the five domains of the Inquiry Discipline Framework, their regulatory objects, observable indicators, and the risks associated with insufficient structure or excessive control.

Table 2: Domains and observable indicators of the Inquiry Discipline Framework

Domain	Regulatory object	Observable indicator	Failure at opposite poles
Material and safety	Safe use, distribution, care, and return of materials	Pupils anticipate hazards, report problems, and manage equipment responsibly	Unsafe exploration / rigid prohibition of productive practical work
Procedural and temporal	Coherent sequencing, fair comparison, recording, and pacing	Pupils can explain and monitor the logic of their procedure	Random activity / recipe following without understanding
Collaborative and dialogic	Equitable access to action, talk, disagreement, and decision	Roles rotate; contributions are heard; critique targets ideas	Domination or exclusion / enforced silence and scripted turns
Epistemic	Accountability of questions, evidence, representations, and claims	Pupils preserve anomalies, justify claims, and revise explanations	Opinion exchange / teacher-owned 'correct' conclusion
Self-regulatory	Planning, monitoring, help seeking, persistence, and evaluation	Pupils diagnose obstacles and use supports with decreasing prompting	Abandonment / permanent dependence on surveillance

Note. The final column shows how both insufficient structure and excessive control can undermine inquiry.

Table 3 then maps this framework across the inquiry cycle by aligning each phase with its characteristic risks, the purposeful structures provided by the teacher, and the responsibilities progressively transferred to pupils. Its final column emphasises that scaffolding is incomplete unless pupils gradually develop the capacity to perform its regulatory functions with increasing independence.

Table 3: Regulatory architecture across an inquiry cycle

Phase	Characteristic risk	Purposeful teacher structure	Responsibility to be transferred
Orientation	Dispersed attention; premature explanation	Focus the phenomenon; establish observation and safety norms; preserve uncertainty	Sustain attention and generate questions
Conceptualisation	Questions too broad, untestable, or teacher-owned	Model criteria; use question stems; co-construct boundaries	Formulate and refine an investigable question
Investigation	Unsafe handling; random trials; lost data; role monopoly	Use material routines, role rotation, checkpoints, and contingent prompts	Coordinate action, monitor the plan, and record evidence
Conclusion	Description without explanation; selective use of results	Prompt claim–evidence links; surface anomalies; calibrate certainty	Construct and qualify an evidence-based conclusion
Discussion	Status-based talk; personal disagreement; teacher verdict	Sequence contrasting ideas; revoice; request evidence; protect critique	Challenge, defend, and revise ideas respectfully
Reflection	Activity ends without learning from the process	Prompt review of decisions, participation, and next steps	Evaluate both scientific reasoning and group regulation

Note. Inquiry phases adapted conceptually from Pedaste *et al.* [12]; regulatory analysis developed for this review.

7. Applications in Primary Science

Consider an investigation of which materials keep water warm. An authoritarian version gives every group an identical method, demands silence, and treats the expected ranking as the correct answer. A permissive version distributes cups and insulation materials and tells pupils to discover what works. Disciplined inquiry begins with a meaningful design problem, establishes non-negotiable rules for warm water and thermometers, and co-constructs criteria for a fair comparison. Groups may choose insulation combinations, but they must record starting temperature, elapsed time, and material thickness. The teacher supports measurement and asks groups to justify design changes. Choice is real because the evidence is not predetermined; structure is strong because the comparison must remain interpretable.

A second example is the construction of simple electrical circuits. Material discipline includes checking components and prohibiting unsafe connections. Procedural discipline involves systematic testing rather than random assembly. Collaborative discipline ensures that building, recording, and explaining rotate among pupils. Epistemic discipline requires diagrams that correspond to actual circuits and explanations that account for a complete conducting path. Self-regulation appears when groups diagnose a non-working circuit by checking connections, components, and their own diagram before requesting teacher rescue.

A shadows inquiry illustrates the value of controlling some decisions while opening others. The teacher may fix the light source and darkened area for safety and comparability, while pupils decide how to investigate the relation among light, object, and screen. Younger pupils may need a three-position template; more experienced pupils may design a measurement table. The disciplinary boundary is that claims must be supported by recorded positions and shadow sizes. The opportunity for agency lies in designing tests, representing patterns, and explaining them.

These examples show why the same visible rule can have different pedagogical meanings. ‘Only one person collects materials’ may be an arbitrary restriction, a strategy for safe movement, or a temporary routine that will later be transferred to groups. The teacher should communicate purpose and periodically review necessity. Rules that no longer protect learning become ritual; choices that do not affect reasoning become decorative autonomy.

Digital technologies create similar requirements. Simulations, tablets, sensors, and collaborative documents can expand access to phenomena and support rapid representation, but they also introduce attentional and procedural demands. A systematic review of technology in elementary inquiry science found varied uses across inquiry phases and highlighted the importance of pedagogical integration rather than technology alone [31]. Digital discipline therefore includes file naming, device sharing, traceable data handling, and a clear relation between screen activity and the scientific question.

Across contexts, the teacher can use a small set of high-leverage routines: a visible inquiry question; colour-coded equipment trays; rotating role cards; stop-and-check points; a public evidence board; and a closing reflection on both findings and group regulation. Routines reduce avoidable cognitive and managerial load. Their value, however, depends on whether they serve thinking. When routines become ends in themselves, inquiry contracts into orderly task completion.

8. Equity, Language, and Belonging

Discipline is never neutral in its effects. Expectations about eye contact, volume, turn taking, speed, or ‘appropriate’ participation may reflect cultural and linguistic assumptions rather than necessities of scientific work. A framework intended to avoid authoritarianism must therefore ask whether a rule protects safety, equitable participation, or epistemic quality—and whether it does so without imposing avoidable barriers. The purpose is not to abandon common norms but to subject them to pedagogical justification.

Inquiry can amplify inequity when participation is left informal. Pupils with greater confidence, prior experience, linguistic fluency, or perceived scientific ability may claim equipment and interpretive authority. Role rotation can broaden access, but rigid roles can also reproduce hierarchy if one child repeatedly records while another conducts the consequential manipulation. Teachers should track who asks questions, touches materials, interprets results, and reports conclusions. Equity concerns access to epistemic work, not only visible busyness.

Language is particularly important in primary science. Pupils may understand a phenomenon before they can express it in the specialised register expected by school. Instructional support should connect everyday descriptions, gestures, drawings, tables, and scientific terms. Research in elementary inquiry classrooms indicates that instructional support is related to both science content knowledge and academic language, underscoring the need to design these goals together [32]. Dialogic discipline gives pupils time to formulate ideas, allows multimodal contributions, and treats clarification as a normal part of inquiry.

Predictable structure can be inclusive because it reduces uncertainty about what will happen, how help can be obtained, and how participation is recognised. Yet predictability must not become inflexibility. Some pupils may need adapted tools, additional rehearsal, alternative recording modes, or shorter regulatory intervals. Equitable structure holds common intellectual goals while varying access supports. Fairness is not identical treatment; it is responsible design for meaningful participation.

Belonging is also protected by the treatment of error. If inaccurate predictions or anomalous data invite ridicule or rapid correction, pupils learn to conceal uncertainty. A disciplined inquiry community regards error as information while maintaining standards for honesty and care. Pupils are accountable for reporting what occurred, not for producing the result the teacher expected. This norm is both ethical and epistemic: trustworthy evidence depends on psychological safety.

9. Implications for Teaching and Teacher Education

For classroom practice, the framework suggests beginning planning with two parallel questions: What scientific thinking should pupils undertake, and what regulation will make that thinking possible? A lesson plan should identify the consequential decisions reserved for pupils, the non-negotiable boundaries, the likely points of difficulty, and the evidence that will indicate readiness for greater independence. This approach integrates management with pedagogy instead of appending behaviour rules after the activity is designed.

Teachers also need a repertoire of interventions differentiated by function. A safety directive may appropriately be immediate and non-negotiable. A procedural prompt may direct attention to the plan. An epistemic question may expose an unsupported inference. A collaborative intervention may redistribute a role or invite an unheard voice. A self-regulatory prompt may ask pupils to diagnose what is preventing progress. The surface form—directive, question, model, cue, or feedback—should follow the purpose and urgency of the situation.

Teacher education should therefore move beyond generic advice to ‘manage the class’ during practical work. Prospective teachers need opportunities to analyse video, rehearse material routines, anticipate inquiry bottlenecks, and practise contingent scaffolding. They should learn to distinguish productive noise from disengagement, exploratory deviation from unsafe conduct, and genuine autonomy from abandonment. Professional preparation should also attend to prospective teachers’ efficacy beliefs, because confidence in teaching physics forms part of their readiness to organise demanding practical and inquiry activities. The assessment of 408 Greek pre-service primary teachers illustrates the value of examining such beliefs alongside pedagogical knowledge and classroom practice [33]. Evidence from inquiry-based laboratory activities further indicates that conceptual understanding and teaching self-efficacy can be developed together when pre-service teachers participate in appropriately structured investigations [34]. The quality of inquiry teaching is visible in these moment-to-moment judgements, not only in the written lesson plan [35].

Assessment practices must align with the framework. If only the final correct answer is graded, pupils receive little reason to preserve unexpected data, document revisions, or share uncertainty. Assessment can include the quality of the question, the appropriateness of a procedure, the traceability of evidence, the responsiveness of a conclusion, and reflection on collaboration. Group products should be complemented by individual explanations so that shared inquiry does not obscure individual understanding.

School-level conditions also matter. Inquiry requires preparation time, accessible storage, maintained equipment, manageable transitions, and agreement about safety procedures. Longitudinal evidence from Greek primary education indicates that, despite progress in experimental physics teaching, persistent barriers related to material infrastructure, teacher preparation, and curriculum implementation continue to restrict its sustained classroom use [36]. Teacher-related conditions are equally important, because attitudes towards experimentation may influence teachers’ willingness to organise practical and inquiry-based physics activities. Evidence from Greek primary education indicates that teachers’ educational backgrounds are associated with their attitudes towards using experiments in physics teaching [37]. Administrators who evaluate every lively science lesson as disorder may discourage inquiry; those who equate student-centred learning with teacher non-intervention may underestimate professional orchestration. A common language of structured inquiry can support observation and professional dialogue by focusing attention on purpose, participation, and transfer.

Curriculum documents can contribute by specifying inquiry practices and developmental expectations rather than simply listing activities. The recent Greek primary science curriculum, for example, places observation, experimentation, reasoning, and inquiry at the centre of science learning [38]. Enactment will depend on whether teachers are supported to build the regulatory architecture those practices require. Research on primary science teaching identifies inadequate resources, limited teacher preparation, and difficulties sustaining pupil engagement as interconnected obstacles requiring coordinated pedagogical and institutional responses [39]. Curriculum ambition without material and pedagogical infrastructure risks widening the gap between intended and experienced inquiry.

10. Future Research

The framework generates several propositions for empirical study. First, the relation between structure and inquiry quality is likely to be curvilinear and domain specific. Too little procedural structure may fragment an investigation, whereas too much may eliminate design decisions. Strong safety structure may remain beneficial even when epistemic responsibility is largely transferred. Studies should therefore measure domains separately rather than classify whole classrooms as simply structured or unstructured.

Second, transfer should be examined as a process. Longitudinal and microgenetic studies could trace how a teacher cue becomes peer regulation and eventually pupil self-prompting. Video analysis, pupil work, stimulated recall, and talk analysis would make it possible to identify when scaffolds are appropriated, bypassed, or made unnecessary. The temporal grain matters because a lesson can contain rapid movement between teacher regulation and pupil agency.

Third, research should investigate differential access to regulatory and epistemic roles. Measures might record who handles materials, proposes procedures, challenges claims, interprets representations, and reports findings. Such data would test whether participation structures actually redistribute authority or merely create the appearance of collaboration. Attention to multilingual pupils, pupils with disabilities, and different classroom cultures is essential for determining which structures widen or restrict participation.

Fourth, intervention research could compare professional-learning designs centred on the IDF with generic classroom-management training. Outcomes should include not only behaviour and achievement but also the quality of questions, evidence use, dialogic participation, safety competence, and self-regulatory transfer. Observational instruments could code the purpose, timing, and fading of teacher interventions.

Finally, research should examine the framework across topics and resource conditions. Practical investigations with physical materials may foreground safety and coordination; modelling, fieldwork, and digital inquiry may place different demands on representation, movement, or data provenance. Testing the IDF across these forms would refine its boundaries and prevent it from becoming a universal checklist detached from scientific content.

11. Discussion

The analysis reframes school discipline as part of the epistemic and social design of primary science. Inquiry requires freedom to ask, test, interpret, and revise, but those freedoms become meaningful only within arrangements that protect safety, evidence, time, and participation. The resulting position rejects both authoritarian control and pedagogical laissez-faire. Structure is justified when it expands pupils' capacity to undertake scientific work; it becomes authoritarian when it demands submission, forecloses legitimate reasoning, or retains control that pupils are ready to exercise.

This position helps reconcile evidence that might otherwise appear contradictory. Inquiry-based learning can improve conceptual understanding, scientific skills, and motivation, yet open inquiry can create management and guidance difficulties [7]. Guidance produces positive effects across inquiry activities, performance, and learning outcomes [5], but student authority remains important for productive disciplinary engagement [15]. The synthesis is not a compromise in which teachers direct half the lesson and pupils control the other half. It is an adaptive allocation of regulatory and epistemic responsibility.

The IDF adds specificity to this allocation. Material and safety discipline protects participation in practical work. Procedural and temporal discipline maintains a traceable investigation. Collaborative and dialogic discipline distributes access to ideas and action. Epistemic discipline holds explanations accountable to evidence. Self-regulatory discipline makes the developmental purpose explicit. Together they explain why an apparently calm classroom may support little inquiry and why an animated classroom may nevertheless be rigorously disciplined.

The framework also shifts attention from pupil deficit to instructional diagnosis. Disruption during inquiry is not always evidence of poor character or weak motivation. It may signal an inaccessible question, insufficient equipment, ambiguous roles, an unproductive group status hierarchy, or a scaffold that was removed too early. This does not eliminate pupil responsibility. It locates responsibility within a designed system and makes teacher action more precise.

Two cautions remain. First, no framework can replace contextual judgement. Age, prior experience, content, materials, time, and class composition alter the necessary degree of support. Second, the language of self-regulation should not be used to transfer all responsibility to children while leaving unequal conditions untouched. Pupils learn disciplined inquiry through participation in well-resourced, respectful communities; they cannot individually compensate for chronically incoherent design.

Within these limits, structure without authoritarianism offers a productive orientation for primary science. It treats teacher authority as legitimate when it is transparent, proportionate, revisable, and directed towards pupils' growing competence. It treats pupil voice as substantive when pupils make decisions that affect questions, evidence, representations, or explanations. Most importantly, it recognises that classroom order and intellectual openness are not competing goods when both are organised around the purposes of inquiry.

12. Conclusion

Inquiry-based primary science flourishes when discipline is understood as the shared regulation of safe, equitable, and evidence-responsive activity. The Inquiry Discipline Framework identifies five interdependent domains through which this regulation is organised: material and safety discipline, procedural and temporal discipline, collaborative and dialogic discipline, epistemic discipline, and self-regulatory discipline. Together, these domains make visible the regulatory infrastructure of inquiry and provide a practical language for lesson planning, classroom observation, teacher education, and empirical research.

The teacher's task is to establish intelligible boundaries, provide scaffolds responsive to pupils' developing competence, and transfer consequential responsibility when pupils are ready to exercise it. The quality of discipline should therefore be judged not by silence, speed, or compliance, but by whether pupils can participate safely, reason together, preserve and interpret evidence, justify conclusions, and increasingly regulate their own inquiry. Understood in this way, discipline is not the price paid for inquiry; it is one of the conditions that makes inquiry possible.

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