

Inquiry Based Laboratory Instructions (IBLI) and the Right to Education Act 2009: A Conceptual Analysis of Child Centred and Activity Based Learning Principles

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Abstract

The Right of Children to Free and Compulsory Education (RTE Act, 2009) emphasizes child centred, activity based, discovery oriented and exploratory learning through its curricular provisions under Section 29. Although these principles have important implications for science education, limited research has systematically examined their conceptual relationship with Inquiry Based Laboratory Instructions (IBLI). The present paper addresses this gap by examining how IBLI can be aligned with the child centred and activity based learning principles reflected in the RTE Act. A conceptual and policy analysis methodology was adopted, involving examination of the RTE Act, Government of India policy documents, the National Curriculum Framework for School Education (NCFSE) 2023, and relevant scholarly literature on inquiry based science and laboratory learning. The analysis conceptualises IBLI as a learner centred pedagogical approach involving questioning, prediction, investigation, experimentation, observation, evidence collection, analysis, explanation and reflection. The findings indicate substantial conceptual correspondence between IBLI and the RTE principles of learning through activities, discovery and exploration, child centred learning, all round development and continuous evaluation. The analysis further indicates that IBLI can provide a pedagogical mechanism for translating these principles into laboratory based scientific learning, with potential relevance to scientific process skills, conceptual understanding, reasoning and problem solving. However, the paper does not claim that IBLI is legally mandated by the RTE Act or that it produces causal learning effects. The study proposes an IBLI-RTE alignment framework and discusses implications for science curriculum, teacher education, assessment and inclusive laboratory practice.

Keywords: Inquiry Based Laboratory Instructions (IBLI), Right to Education Act 2009, Activity Based Learning, Science Education, Inquiry Based Learning, Experiential Learning.

1. Introduction

Science education extends beyond the acquisition of factual knowledge and requires learners to engage in observation, questioning, investigation, experimentation, evidence collection and scientific reasoning.

Consequently, contemporary approaches to science teaching increasingly emphasise active learner participation in scientific practices rather than the passive reception of information from teachers or textbooks. Inquiry Based Laboratory Instructions (IBLI) represent such an approach by organising laboratory learning around questions, problems or phenomena that encourage learners to investigate, collect evidence, interpret observations and construct explanations. In this approach, the laboratory is transformed from a setting for performing predetermined procedures into an environment for active scientific investigation and knowledge construction. The principles underlying IBLI have important connections with India's broader educational policy framework. The Right of Children to Free and Compulsory Education (RTE Act, 2009), particularly Section 29, emphasises the all-round development of children, development of knowledge and potential, physical and mental abilities, and learning through activities, discovery and exploration in a child friendly and child centred manner. The provision also emphasises freedom from fear, trauma and anxiety and comprehensive and continuous evaluation. These principles provide a relevant policy lens for examining pedagogical approaches that promote active, experiential and learner centred learning. In particular, Section 29(2)(e), with its emphasis on activities, discovery and exploration in a child friendly and child centred manner, demonstrates conceptual correspondence with inquiry oriented laboratory learning. Within science education, IBLI can operationalise these principles through a sequence of questioning, prediction, investigation, experimentation, observation, evidence analysis, explanation and reflection. Such processes encourage learners to participate actively in constructing scientific understanding and developing scientific process skills, conceptual understanding, reasoning and problem solving abilities. The approach is also consistent with constructivist, experiential and discovery oriented perspectives, which regard learners as active participants in knowledge construction. The conceptual relationship between IBLI and the RTE principles can therefore be understood through the progression from policy principles to pedagogical processes and potential learning outcomes. The activity based, discovery oriented, exploratory and child centred principles reflected in Section 29 provide the policy foundation, while IBLI provides a laboratory based pedagogical mechanism through which learners engage with scientific phenomena. The process includes engaging with a phenomenon, formulating questions, making predictions, planning investigations, conducting experiments, observing, collecting and analysing evidence, constructing explanations and reflecting on learning. The alignment between IBLI and the RTE Act is primarily conceptual and pedagogical rather than legal. IBLI corresponds particularly with the principles of learning through activities, discovery and exploration and child centred learning reflected in Section 29. Hands on laboratory investigations provide opportunities for learners to manipulate apparatus, observe phenomena, ask questions, make predictions, investigate problems and interpret evidence. Similarly, guided inquiry, collaboration and learning from errors can contribute to a supportive and child friendly learning environment. Questioning, discussion, reflection and evidence based explanation can further encourage learners to express their ideas and participate actively in the learning process. This alignment also extends to all round development, the development of knowledge and potential, physical and mental abilities, and comprehensive and continuous evaluation. Laboratory activities can engage learners cognitively, practically, collaboratively and reflectively, while practical performance, observation, laboratory records, explanations and reflection can provide opportunities to assess understanding and application.

The relationship is further strengthened by the National Curriculum Framework for School Education (NCF-SE) 2023, which describes inquiry oriented science learning through observation,

experimentation, inference, communication and discovery. However, the present paper does not interpret this correspondence as evidence that the RTE Act mandates IBLI. Rather, IBLI is examined as a pedagogical approach that is consistent with selected child centred and activity based principles reflected in the Act. Moreover, since the statutory entitlement of the RTE Act concerns children aged 6-14 years, its application to secondary science education should be understood cautiously as a broader policy and pedagogical foundation, with NEP 2020 and NCF-SE 2023 providing more direct contemporary curricular support.

2. Theoretical Framework

The theoretical framework of the present study is based on the assumption that effective science learning occurs when learners actively construct knowledge through experience, inquiry, exploration and reflection. The framework integrates Constructivist Learning Theory, Experiential Learning Theory, Discovery Learning Theory, and the child centred and activity based learning principles reflected in Section 29 of the Right of Children to Free and Compulsory Education (RTE Act, 2009). Constructivism provides the primary theoretical foundation for Inquiry Based Laboratory Instruction (IBLI), as it conceptualises learners as active constructors of knowledge rather than passive recipients of information. Within IBLI, students engage in questioning, prediction, investigation, observation, evidence collection, analysis and explanation, while teachers provide appropriate guidance and scaffolding. Experiential Learning Theory complements this perspective by explaining how laboratory experiences can be transformed into learning through reflective observation, conceptualisation and subsequent experimentation. Discovery Learning Theory further supports the inquiry process by emphasising exploration and the learner's active involvement in discovering relationships and principles. These theoretical perspectives are consistent with the child centred and activity based learning principles articulated in Section 29 of the RTE Act, particularly its emphasis on learning through activities, discovery and exploration in a child friendly and child centred manner. Accordingly, the present framework conceptualises IBLI as a pedagogical mechanism through which these principles can be operationalised in science learning. The framework assumes that appropriately designed inquiry based laboratory experiences can provide learners with opportunities to construct scientific knowledge, develop scientific process skills, engage in evidence based reasoning and apply their understanding to new situations. The integrated framework therefore establishes a conceptual relationship between policy principles, learning theories, instructional processes and expected learning outcomes: RTE Section 29 and child centred principles provide the policy foundation; constructivism, experiential learning and discovery learning provide the theoretical foundation; IBLI represents the pedagogical approach; and scientific process skills, conceptual understanding, scientific reasoning and problem solving represent the principal learning outcomes.

3. Conceptual Framework

The conceptual framework of the present study establishes a relationship between the child centred and activity based learning principles reflected in Section 29 of the Right of Children to Free and Compulsory Education (RTE) Act, 2009 and Inquiry Based Laboratory Instructions (IBLI) as a pedagogical approach to science learning. The framework positions the RTE principles of activity, discovery, exploration, child centred learning and all round development as the policy foundation for inquiry oriented laboratory instruction. Within this framework, IBLI represents the central pedagogical

construct through which learners engage actively in scientific investigation. The instructional process involves a sequence of engaging with a phenomenon, formulating questions, making predictions, planning investigations, conducting experiments, observing phenomena, collecting and analysing evidence, constructing explanations and reflecting on the learning process. This process shifts laboratory learning from the mechanical execution of predetermined procedures towards active investigation and evidence based knowledge construction. The framework proposes that participation in IBLI may contribute to the development of scientific process skills, conceptual understanding, scientific reasoning, problem solving abilities, laboratory competencies, critical thinking and scientific communication. These outcomes represent the expected learning dimensions associated with inquiry oriented science learning rather than predetermined causal effects. The framework also recognises that the implementation and potential outcomes of IBLI may be influenced by contextual and moderating factors, including laboratory resources, teacher preparedness, institutional support, instructional time, class size, students' prior knowledge and classroom conditions. Consequently, the conceptual framework views IBLI not as an isolated instructional technique but as a pedagogical process situated within a broader policy, institutional and classroom context. Overall, the framework proposes the following conceptual relationship: the child centred and activity based principles of the RTE Act provide the policy foundation; IBLI operationalises these principles through inquiry oriented laboratory processes; and sustained engagement in these processes is expected to support the development of students' scientific competencies and meaningful science learning.

4. Literature review

The Right of Children to Free and Compulsory Education (RTE Act, 2009) provides an important policy foundation for child centred and activity based learning in India. Section 29 emphasises the all-round development of children, development of their knowledge and potential, physical and mental abilities, and learning through activities, discovery and exploration in a child friendly and child centred manner (Government of India, 2009). These provisions are particularly relevant to science education because they emphasise active engagement rather than the passive acquisition of factual information. The Government of India's advisory on the implementation of Section 29 further highlights the need to translate these curricular principles into appropriate learner centred educational practices (Government of India, 2012). Accordingly, the RTE framework provides a useful policy lens for examining pedagogical approaches that encourage learners to participate actively in the learning process. The relevance of these provisions becomes clearer when considered in relation to Inquiry Based Laboratory Instruction (IBLI). IBLI involves questioning, prediction, investigation, experimentation, observation, evidence collection, analysis and explanation, thereby positioning learners as active participants in scientific learning. Such processes correspond conceptually with the RTE emphasis on activities, discovery and exploration. In laboratory settings, inquiry can transform practical work from the mechanical performance of prescribed experiments into opportunities for learners to investigate phenomena, interpret evidence and construct scientific explanations. The emphasis of Section 29 on freedom from fear, trauma and anxiety is also relevant to inquiry oriented learning because meaningful inquiry requires learners to ask questions, communicate ideas, discuss observations and learn from errors within a supportive environment. Similarly, the provision concerning comprehensive and continuous evaluation has conceptual relevance to laboratory learning, where learners' understanding may be assessed through practical performance, observation, laboratory records, explanation and reflection. The

National Curriculum Framework for School Education (NCF-SE, 2023) further strengthens this connection by emphasising observation, experimentation, inference, communication and discovery as components of inquiry oriented science learning (NCERT, 2023). Research examining the implementation of the RTE Act indicates that translating policy principles into educational practice remains an important challenge. Malvankar (2018) highlighted concerns related to the implementation and quality dimensions of elementary education under the RTE framework, while Rani and Jaiswal (2016) reported that provisions of the Act were only partially implemented in selected schools in Meerut, Uttar Pradesh. These findings suggest that policy provisions alone may not ensure their effective translation into classroom practice and that teacher preparedness, institutional support and appropriate learning conditions are important considerations. This observation is particularly relevant to IBLI because activity based, child centred and exploratory learning requires teachers to provide appropriate guidance, scaffolding, resources and opportunities for learner participation. Within science education, inquiry based approaches have increasingly been examined as means of promoting active, meaningful and skill oriented learning. Kanter and Konstantopoulos (2010) reported improved science achievement among minority students when inquiry based curricula were supported by strong teacher knowledge and pedagogy. Blanchard et al. (2010) similarly reported learning benefits associated with guided inquiry laboratory activities compared with traditional verification oriented laboratory work. Research involving prospective teachers has also indicated the potential of inquiry oriented approaches for developing understanding of the nature of science, scientific process skills and attitudes towards experimentation (Ozgelen et al., 2012; Yakar & Baykara, 2014). Irwanto et al. (2019) further examined inquiry based laboratory instruction in relation to critical thinking and scientific process skills. Other studies have explored laboratory skills, scientific inquiry and learner participation, including Argument-Driven Inquiry and guided inquiry environments (Eymur, 2018; Cetin, 2020, 2021; Hernandez et al., 2020). Technological developments have further expanded opportunities for inquiry oriented science learning through virtual and online laboratory environments. Studies by Nedungadi et al. (2015), Mutlu and Sesen (2020), and Lai et al. (2021) indicate the potential of technology supported inquiry for supporting scientific reasoning, conceptual understanding, attitudes and transfer of learning. More recent literature has emphasised the importance of appropriate guidance, reflection and inclusive participation in inquiry based science education (Gericke et al., 2022; Orosz et al., 2023; Denton & Kulesza, 2024; Mekonnen, 2025). Collectively, this literature suggests that the educational value of inquiry depends not simply on increasing practical activity but on the quality of instructional design, teacher support and learning conditions. However, existing research has largely examined RTE implementation and inquiry based science education as separate areas. Limited attention has been given to systematically examining how the child centred, activity based, discovery oriented and exploratory principles reflected in Section 29 can be operationalised through IBLI. Therefore, the present study addresses this gap by examining the conceptual and pedagogical alignment between the RTE Act, 2009 and Inquiry Based Laboratory Instruction in science education.

5. Research Gap

Existing literature highlights the value of inquiry based science and laboratory learning for active participation, scientific skills, conceptual understanding and learner centred pedagogy. However, limited research has examined how the activity, discovery, exploration and child centred principles of Section 29 of the RTE Act, 2009 can be operationalised through Inquiry Based Laboratory Instructions (IBLI).

Further, insufficient attention has been given to IBLI in relation to teacher education, marginalised learners and inclusive laboratory participation within the Indian context. A clear IBLI-RTE alignment framework connecting statutory principles with inquiry processes and potential scientific competencies is also lacking. Therefore, the present study examines this conceptual and pedagogical correspondence.

6. Research Methodology

The paper adopts a conceptual and policy analysis approach. Relevant provisions of the RTE Act, 2009 and Government of India curriculum and policy documents were examined alongside scholarly literature on inquiry based science education. The primary policy source was the RTE Act, 2009 and the Government of India's advisory concerning implementation of Section 29. The National Curriculum Framework for School Education (NCF-SE) 2023 was examined to establish the contemporary curriculum connection with inquiry oriented science education. Scholarly literature on inquiry based science education was reviewed to identify evidence concerning conceptual understanding, scientific skills, motivation, attitudes and teacher competencies. Because this is a conceptual paper, no primary participants, intervention or statistical analysis were involved. Therefore, the paper does not make claims about the causal effectiveness of IBLI in a particular population.

7. Objectives of the Study

1. To analyse the conceptual alignment between IBLI and the child centred, activity based, discovery oriented and exploratory principles reflected in Section 29 of the RTE Act 2009.
2. To develop an analytical framework connecting selected RTE principles with inquiry based laboratory processes and potential science learning outcomes.
3. To examine the correspondence between Inquiry Based Laboratory Instructions (IBLI) and selected key provisions of the RTE Act 2009.
4. To examine how IBLI can support scientific competencies through activity, discovery and exploration.
5. To identify implications of this alignment for science curriculum, teacher education and laboratory practice.

8. Significance of the Study

The significance of the present study lies in establishing a conceptual and pedagogical connection between Inquiry Based Laboratory Instructions (IBLI) and the child centred and activity based learning principles reflected in Section 29 of the Right of Children to Free and Compulsory Education (RTE) Act, 2009. The study provides a framework for understanding how the principles of activity, discovery, exploration and child centred learning can be translated into meaningful laboratory based science learning. For science education, the study highlights how IBLI can shift laboratory instruction from the mechanical performance of predetermined experiments towards questioning, investigation, experimentation, observation, evidence analysis, explanation and reflection. These processes provide opportunities for developing scientific process skills, conceptual understanding, scientific reasoning, problem solving and scientific communication. The study is also significant for teacher education, as it highlights the importance of preparing prospective science teachers to design and facilitate inquiry oriented laboratory experiences using appropriate guidance, scaffolding and formative assessment. From an equity perspective, the framework emphasises meaningful participation and access to experiential

science learning for diverse and marginalised learners, while recognising the importance of adequate resources, teacher preparedness, institutional support and instructional time. At the policy level, the study connects RTE principles with contemporary directions in science education under NEP 2020 and NCF-SE 2023. Importantly, IBLI is presented as a pedagogical approach consistent with selected RTE principles, not as a statutory requirement. Overall, the study provides a conceptual foundation for future empirical research on inquiry based laboratory instruction, inclusive science education, teacher preparation and scientific competencies.

9. Alignment of Inquiry Based Laboratory Instructions (IBLI) with the Child Centred and Activity Based Learning Principles of the Right to Education Act 2009

Inquiry Based Laboratory Instructions (IBLI) is conceptually aligned with the child centred, activity based, discovery oriented and exploratory learning principles reflected in Section 29 of the RTE Act, 2009. IBLI translates these principles into science learning through questioning, prediction, investigation, experimentation, observation, evidence collection, analysis, explanation and reflection. Its learner centred approach supports active participation, knowledge construction and the development of scientific process skills, conceptual understanding, reasoning and problem solving abilities. The use of practical activities, exploration and guided inquiry corresponds particularly with Section 29 emphasis on learning through activities, discovery and exploration. IBLI also supports continuous assessment through observation, practical performance, laboratory records and reflective activities.

Table 1. Conceptual Alignment of Inquiry Based Laboratory Instructions (IBLI) with the RTE Act 2009

RTE act 2009 Principle	Inquiry Based Laboratory Instructions (IBLI)	Meaning for learning
All round development	Cognitive, practical, collaborative and reflective laboratory learning.	Development beyond factual knowledge
Building knowledge, potential and talent	Students learn by conducting experiments and investigations.	Learners actively develop understanding and capabilities
Development of physical and mental abilities	Manipulation of apparatus, observation, reasoning and experimentation	Opportunities for practical and intellectual engagement
Learning through activities	Handson laboratory investigation	Learning through meaningful learner participation
Discovery and exploration	Inquiry questions, prediction and experimentation	Learners investigate questions and phenomena
Child Centred learning	Student questioning, decision making and investigation	Learners participate actively in the learning process
Child friendly learning	Guided inquiry, collaboration and learning from errors	Supportive and non-threatening learning

		environment
Freedom from fear and anxiety	Questioning, discussion, reflection and evidence based explanation.	Learners should be able to express views freely
Comprehensive and continuous evaluation	Practical performance, observation, laboratory records, explanation and reflection	Assessment should consider understanding and application

10. Discussion

The present analysis demonstrates a substantial conceptual alignment of Inquiry Based Laboratory Instructions (IBLI) with the child centred and activity based learning principles of the Right to Education (RTE Act, 2009). The alignment is particularly evident in the emphasis of Section 29 on learning through activities, discovery and exploration in a child friendly and child centred manner. IBLI translates these principles into laboratory based science learning through questioning, prediction, investigation, experimentation, observation, evidence collection, analysis, explanation and reflection. Thus, laboratory learning can move beyond the mechanical performance of predetermined procedures towards active learner participation and evidence based construction of scientific understanding. The alignment also extends to the broader principles of all round development, development of knowledge and potential, physical and mental abilities, freedom from fear and anxiety, and comprehensive and continuous evaluation. Practical investigation, collaborative activities, observation, reasoning and reflection provide opportunities for learners to engage cognitively, practically and socially. Similarly, observation of practical performance, laboratory records, explanations and reflective activities can support assessment of understanding and application rather than factual recall alone. This conceptual relationship is further supported by NCFSE 2023, which emphasises observation, experimentation, inference, communication and discovery in science learning. However, the analysis does not suggest that inquiry automatically produces improved achievement. The effectiveness of IBLI depends on appropriate teacher guidance and scaffolding, laboratory resources, instructional time, classroom conditions and meaningful assessment. Therefore, the significance of IBLI lies not merely in increasing laboratory activities but in transforming them into structured, child centred processes of investigation, discovery and evidence based learning. Importantly, IBLI should be understood as a pedagogical approach consistent with selected RTE principles, rather than as a teaching method legally mandated by the RTE Act.

11. Conclusion

The present conceptual and policy analysis establishes a substantial relationship between Inquiry Based Laboratory Instructions (IBLI) and the child centred, activity based, exploratory and discovery oriented learning principles reflected in Section 29 of the Right of Children to Free and Compulsory Education (RTE Act, 2009). The analysis indicates that the strongest correspondence lies in the emphasis on learning through activities, discovery and exploration in a child friendly and child centred manner. These principles provide a relevant policy perspective for examining how science learning can move beyond the transmission and reproduction of factual knowledge towards active learner participation. Within this context, IBLI provides a pedagogical framework through which these principles can be translated into

laboratory based science learning. Its processes of questioning, prediction, investigation, experimentation, observation, evidence collection, analysis, explanation and reflection encourage learners to participate actively in the construction and application of scientific knowledge. Such processes have the potential to support scientific process skills, conceptual understanding, scientific reasoning, problem solving, laboratory competencies and scientific communication. The proposed alignment framework therefore connects RTE principles with concrete instructional processes and potential dimensions of scientific learning. The analysis also demonstrates that the relationship between IBLI and the RTE framework should be understood carefully. IBLI is not a teaching method prescribed or mandated by the RTE Act, 2009. Rather, it represents a pedagogical approach that is conceptually and pedagogically consistent with selected curricular principles articulated under Section 29. Furthermore, the statutory entitlement under the RTE Act concerns children aged 6-14 years and therefore primarily relates to elementary education. Its application to secondary school science should consequently be understood as a broader policy and pedagogical foundation rather than as a direct statutory requirement. For secondary science education, contemporary frameworks such as NEP 2020 and NCF-SE 2023 provide a more direct curricular context for inquiry, experimentation, exploration and learner centred science learning. The study further highlights that the educational value of IBLI cannot be assumed solely from the presence of laboratory activities. Effective implementation requires appropriate teacher guidance and scaffolding, adequate laboratory resources, sufficient instructional time, supportive classroom environments and meaningful assessment practices. These conditions are particularly important for ensuring that inquiry based laboratory experiences remain accessible and meaningful to diverse learners. Overall, the IBLI-RTE alignment framework provides a conceptual foundation for connecting educational policy with inquiry oriented science pedagogy. It has implications for curriculum design, teacher education, laboratory practice, formative assessment and inclusive participation. However, because the present study is conceptual rather than empirical, it cannot establish causal effects of IBLI on students' learning outcomes or teachers' instructional practices. Future experimental, quasi experimental and longitudinal research should therefore examine whether the proposed alignment translates into measurable improvements in scientific competencies, inquiry skills, laboratory practices and equitable participation, particularly among diverse and marginalised learners.

12. Scope for Future Research

Future research can empirically investigate the proposed IBLI-RTE alignment through experimental and quasi experimental studies.

Research may examine:

1. The effect of structured IBLI on scientific process skills;
2. The relationship between inquiry based laboratory experiences and conceptual understanding;
3. Development of inquiry facilitation skills among prospective science teachers;
4. Participation of marginalised learners in laboratory activities;
5. Comparison of structured, guided and open inquiry;
6. Effectiveness of IBLI in resource constrained schools;
7. Development of assessment tools for inquiry oriented laboratory learning;
8. Longitudinal effects of sustained inquiry based laboratory experiences; and
9. Relationships among IBLI, NEP 2020, NCF-SE 2023 and inclusive science education.

Future empirical studies should also investigate the contextual conditions under which IBLI can be implemented effectively. These include teacher preparedness, laboratory resources, institutional support, instructional time and assessment practices.

13. Limitations of the Study

The study has several limitations. First, it is conceptual and policy oriented and does not provide empirical evidence of the effectiveness of IBLI. Second, the analysis establishes conceptual correspondence rather than causal relationships. Third, the RTE Act's statutory entitlement concerns children aged 6-14 years. Therefore, its direct application to secondary education should be interpreted cautiously. Fourth, alignment between a policy principle and an instructional approach does not guarantee successful implementation. Teacher preparedness, laboratory resources, time, class size, student characteristics and institutional support may influence implementation. Finally, further empirical research is required to test whether the proposed conceptual alignment translates into measurable changes in scientific competencies, learner participation and teacher practices.

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