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ALIGNING INQUIRY BASED LABORATORY INSTRUCTIONS (IBLI) WITH NEP 2020: A CONCEPTUAL FRAMEWORK FOR TRANSFORMING SCIENCE EDUCATION

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ABSTRACT

Inquiry Based Laboratory Instructions (IBLI) is a learner centered, constructivist teaching-learning approach in which students grasp scientific concepts by asking questions, planning and conducting investigations, collecting and analyzing evidence, drawing conclusions and communicating their findings, rather than simply following predetermined laboratory procedures. In contrast, traditional laboratory methods require students to follow fixed instructions which are given earlier while IBLI encourages learners to develop the ability to conduct scientific investigations and apply scientific practices. This policy represents comprehensive transformation reform the Indian education system, emphasizing holistic, learner centered, experiential, competency based, inquiry driven and inclusive education. The vision of this policy also develops critical thinking, creativity, scientific temper, problem solving, collaboration, communication and other twenty first century competencies. In this context, Inquiry Based Laboratory Instructions (IBLI) provides a pedagogical approach through which learners actively participate in questioning, investigating, experimenting, collecting and analyzing evidence, constructing explanations and communicating scientific understanding. The present study examines the relevance and potential of IBLI as a pedagogical approach for advancing the broader vision of NEP 2020. This study is based on a conceptual analysis of alignment between the principles of IBLI and NEP 2020 including experiential learning, competency based education, learner centered pedagogy, critical thinking, problem solving, creativity, collaboration, scientific temper, multidisciplinary learning, authentic assessment and inclusive education. The paper concludes that IBLI has considerable potential to support the broader transformative vision of NEP 2020 by strengthening meaningful, experiential, inquiry oriented and competency based learning in Indian education.

Keywords: Inquiry Based Laboratory Instructions (IBLI), NEP 2020, Science Education, Competency Based Learning

1 INTRODUCTION

National Education Policy 2020 aims to develop an inclusive and equitable education system by ensuring that every learner has access to quality education and meaningful learning opportunities, irrespective of socio economic differences. It provides a broad and comprehensive framework covering education from the foundational and school levels through higher education, along with vocational education and training in both rural and urban areas. The policy places strong emphasis on the holistic development of individuals by nurturing the ability to think and act rationally while promoting empathy, compassion, resilience, courage, scientific thinking, creative imagination and a strong foundation of ethical values. In this context, NEP 2020 constitutes an important reform in the Indian education system from traditional rote memorization towards competency based, experiential, inquiry oriented and learner centered approaches to education. Science education plays a crucial role in achieving vision of NEP 2020 because scientific temperament is very essential part of human development; it develops scientific literacy, critical thinking, creativity and problem solving abilities for the twenty first century, but questions arises that how this policy implement for achieving their goals, many factors responsible for implementing this policy in which Inquiry Based Laboratory Instructions (IBLI) is also an effective approach for putting the provisions of India's National Education Policy (NEP) 2020 into practice. Inquiry Based Laboratory Instructions (IBLI) is a student centered, constructivist teaching approach in which students learn scientific concepts by asking questions, planning and conducting investigations, collecting and analyzing evidence, drawing conclusions and communicating their findings, rather than simply following predetermined laboratory procedures. In traditional laboratory method where students follow fixed instructions which is given earlier while IBLI encourages learners to think and work like scientists by actively engaging in the process of scientific inquiry. Constructivist Learning Theory introduced by Jean Piaget (1952), Social Constructivism presented by Lev Vygotsky (1978), Kolb's Experiential Learning Theory (1984) & Bruner's Discovery Learning Theory (1961) is the basis of the Inquiry Based Laboratory Instructions (IBLI). The IBLI and NEP 2020 alignment framework conceptualized 6 domains: Inquiry & scientific reasoning, experiential engagement, competency development, collaboration & multidisciplinary learning, equity and inclusion, authentic assessment and reflection. Generally, laboratory learning is predetermined procedures while IBLI is an active and learner centered approach. Its successful implementation depends on teacher preparation, appropriate scaffolding, laboratory infrastructure, curriculum flexibility, assessment reform, institutional support and attention to learner diversity. Evidence from inquiry research also indicates that appropriate guidance is important, particularly for learners who have limited experience with inquiry based learning. Therefore, the contribution of IBLI to NEP 2020 is best understood as a pedagogical pathway through which selected policy aspirations can be translated into classroom and laboratory practice. Future empirical research should validate the proposed framework across different school contexts, subjects, learner groups and levels of inquiry.

1.1 Theoretical Framework

Inquiry Based Laboratory Instructions (IBLI) is supported by several complementary theories of learning that explains how students learn through active investigation and experience. One of the main theoretical foundations of IBLI is Constructivist Learning Theory associated with Jean Piaget (1952). This theory suggests that learners do not simply receive knowledge from teachers they also build their understanding through interaction with their experiences and surroundings. In IBLI, students develop scientific knowledge by asking questions, carrying out experiments, examining evidence and developing explanations from their observations. Social Constructivism given by Lev Vygotsky (1978), this theory explains Learning happens through interacting with teachers and peers. During IBL activities, students can work together, exchange ideas, discuss their observations and get guidance from teachers. Such interactions can help learners strengthen their conceptual understanding and scientific reasoning. Another important foundation is Kolb's Experiential Learning Theory (1984) that explains learning is a continuous process which involves concrete experience, reflection, conceptual understanding and active experimentation. IBLI naturally provides opportunities for learners to learn through reflecting based on their experiences & applying what they have learned. Bruner's Discovery Learning Theory (1961) also supports IBLI by emphasizing learning through exploration and discovery. In addition, the inquiry framework of the National Research Council (2000) highlights questioning, investigation, evidence collection, data analysis, explanation and communication as important elements of scientific inquiry, these theoretical perspectives provide a strong foundation for IBLI and demonstrate its conceptual connection with the NEP 2020 emphasis on experiential, learner centered, competency based and inquiry oriented education. They also provide a basis for examining how IBLI can promote the development of scientific skills, competencies & the broader educational goals of NEP 2020.

1.2 Conceptual Framework

The conceptual framework explains how Inquiry Based Laboratory Instructions (IBLI) can support the implementation of NEP 2020 through the development of students' scientific competencies. IBLI serves as the independent variable and includes questioning, hypothesis formation, experimental planning, investigation, data collection and analysis, evidence based reasoning, reflection and scientific communication. Its effectiveness may be influenced by teacher support, laboratory facilities, learning resources, collaboration, student engagement, and assessment practices. These processes

are expected to strengthen students' understanding, scientific process skills, critical thinking, reasoning, laboratory skills, creativity, collaboration, communication and problem solving, thereby supporting the NEP 2020 goals of competency based, experiential, inquiry oriented and holistic education.

2 LITERATURE REVIEW

Inquiry based laboratory instructions (IBLI) have gained more attention as a way to make studying science more active, meaningful and skill focused. They give students the chance to ask questions, investigate problems, analyze evidence and develop scientific explanations. At the same time, they can strengthen teachers' teaching abilities and help promote more student centered learning. These features are directly linked to the educational priorities of NEP 2020, especially experiential learning, scientific reasoning, skill development and inclusive education. Previous studies provide evidence of the importance of an inquiry oriented approach. Kanter and Konstantopoulos (2009) reported that science achievement improved among minority students when inquiry based curricula were supported by strong teacher knowledge and pedagogy. Blanchard and others (2010) also found that guided inquiry labs offered better learning gains and concept retention compared to traditional verification activities. Studies involving pre service teachers also showed positive results. Ozgelen and others (2012) found that clear and reflective inquiry approaches improved understanding of the nature of science, while Yakar & Baykara (2013) reported improvements in scientific process skills, creative thinking & attitudes toward experiments. Irwanto & others (2019) further highlighted enhancements in critical thinking among prospective teachers. Research has also investigated students' laboratory skills. Eymur (2018) looked at linking Argument Driven Inquiry with improvements in lab skills and self-efficacy, while Cetin (2020, 2021) reported positive changes in students' understanding of scientific inquiry. Hernandez et al. (2020) focused on increased participation of underrepresented learners in a guided inquiry environment. Technology has further boosted these possibilities through virtual and online labs. Nedungadi et al. (2015), Mutlu and Sesen (2020) and Lai et al. (2021) showed how technology assisted inquiry offers potential for scientific reasoning, attitudes, conceptual understanding and transfer of learning. Recent studies shows proper guidance, reflection and inclusive nature (Gericke et al., 2022, Orosz et al., 2023; Denton & Kulesza 2024, Mekonnen 2025). But some challenges and issues remain teaching skill, teacher preparation, infrastructure, equal access etc., there are some incentives like Atal Tinkering Laboratories but their implementation under questionable. Recent studies shift by NEP 2020 to focus competency oriented, learner centered, experience based, curiosity, scientific literacy, scientific attitude, scientific process skills (Singhal and Wadhwa 2022) and this study is close to the feature of Inquiry Based Laboratory Instructions. Sultania and Singh (2024) indicate interdisciplinary learning and practical experiences in NEP 2020. Singh, Chandel & Rao (2025) proved that NEP 2020 connect critical & experiential learning, problem solving, scientific aptitude and learner centered education, similarly Singh (2024) also explain that NEP 2020 plays an important role for learner centered approach. Teacher preparation is also concerning issues which are explained by Ahmed, Khan (2021) & Sharma, Mittal & Zayan (2023) under the idea of NEP 2020. Mishra, Senapati and Mehr (2026) highlighted experiential science for tribal students. These literature reviews explains that IBLI is both laboratory technique as well as pedagogical approach which will be helping in promoting NEP 2020.

2.1 Research Gap

The review related literature shows that NEP 2020 focus on experiential, competency based, inquiry oriented and learner centered education, but also need for a clear pedagogical framework which connect policy goals with learner centered laboratory science teaching approach. While inquiry based learning has received considerable attention in science education, relatively little attention has been given to understanding how Inquiry Based Laboratory Instructions (IBLI) can be systematically aligned with the different educational priorities of New Education Policy 2020.

3 RESEARCH METHODOLOGY

The present study adopted a qualitative conceptual research approach to examine the alignment between Inquiry Based Laboratory Instructions (IBLI) and the major educational priorities of the National Education Policy (NEP) 2020. Since this study doesn't involve primary data collection, experimental interventions or statistical testing, its methodology is mainly focused on systematically reviewing, combining, interpreting and conceptually mapping relevant policy documents and scholars' literature.

Objectives of the Study

- To examine the conceptual alignment between Inquiry Based Laboratory Instructions (IBLI) and the major principles of NEP 2020.
- To develop a conceptual IBLI-NEP 2020 Alignment Framework for promoting experiential, inquiry oriented, competency based, learner centered and inclusive science education
- To analyze the alignment between Inquiry Based Laboratory Instructions (IBLI) and the key provisions of India's NEP 2020.

3.1 Significance of the Study

This study is significant because it has the potential to contribute to educational research, policy development, teacher education and the improvement of classroom practices. NEP 2020 is a major transformation in the education system by moving beyond conventional rote learning towards competency based, experiential, inquiry oriented and learner centered approaches. Within this broader transformation, science education has a crucial role, as the development of scientific temper contributes to scientific literacy, critical thinking, creativity and problem solving abilities that are increasingly important in the twenty first century. Although contemporary educational policy promotes active and learner centered learning, laboratory teaching in many contexts continues to follow conventional teacher directed procedures. Learners have limited opportunities to explore scientific problems in traditional laboratory methods while Inquiry Based Laboratory Instructions (IBLI) offers an alternative pedagogical approach by positioning learners as active participants in the scientific process. Through IBLI, students can engage in questioning, planning investigations, conducting experiments, collecting and analyzing evidence and also developing evidence based scientific explanations. There is also a lack of standardized IBLI models and assessment tools aligned with competency based education in the Indian context. Therefore, this study is needed to explore the potential of IBLI as an effective instructional approach for implementing NEP 2020 and strengthening science education in India. Specifically, the study is important for the following reasons:

- Contribution to the Implementation of NEP 2020
- Improvement of Science Education
- Strengthening Teacher Education
- Development of Scientific Competencies
- Curriculum Development
- Educational Policy Implications
- Contribution to Educational Research
- Social and National Development

3.2 Alignment of Inquiry Based Laboratory Instructions (IBLI) with the Pedagogical Principles of NEP 2020

The pedagogical orientation of Inquiry Based Laboratory Instructions (IBLI) is closely similar with educational vision of NEP 2020. The policy emphasizes a shift from conventional, examination driven education towards a learner centered, experiential, competency oriented and inquiry focused approach to learning. In this context, IBLI provides opportunities for learners to actively engage in scientific investigations construct conceptual understanding and apply scientific attitude in meaningful situations. Inquiry oriented laboratory act can contribute to improved academic performance, deeper conceptual understanding, scientific literacy, reflective thinking. Such experiences also provide opportunities to develop creative & critical thinking, laboratory competencies, scientific self -efficacy and evidence based argumentation. Furthermore, IBLI encourages learners to formulate questions, investigate problems, analyze evidence, communicate findings and reflect on their learning. These characteristics correspond closely with several core principles of NEP 2020 including experiential learning, competency based education and learner centered pedagogy, scientific temper, creativity, collaboration, critical thinking and inclusive education. The following comparison therefore demonstrates the pedagogical correspondence between IBLI and NEP 2020 and highlights the potential of IBLI as a framework for translating the policy's educational aspirations into meaningful science learning practices within the Indian education system.

Table 1: Alignment of NEP 2020 Pedagogical Principles with Inquiry Based Laboratory Instructions (IBLI)

NEP 2020 Principle	Inquiry Based Laboratory Instructions (IBLI)	Similarity
Competency Based Education	Develops scientific process skills, Laboratory competencies and problem solving abilities.	Both focus on developing Competencies rather than rote memorization.
Experiential Learning	Students learn by conducting experiments and investigations.	Both promote learning through direct experience and Practical engagement.
Learner Centered Pedagogy	Students actively participate in Designing and performing investigations.	Both shift the focus from Teacher centered to student centered learning.

Inquiry Based Learning	Students ask questions, formulate hypotheses, investigate, analyze and conclude.	Inquiry is the central teaching learning process in both.
Critical Thinking and Problem Solving	Students examine evidence, interpret findings and address scientific problems.	Both aim to develop higher order cognitive skills.
Scientific Temper	Encourages evidence based Reasoning and scientific investigation.	Both promote scientific temper and rational thinking.
Creativity and Innovation	Students design experiments and explore alternative solutions.	Both promote innovation, Creativity and independent thinking.
Collaborative Learning	Laboratory investigations are often conducted in teams.	Both encourage communication, teamwork and peer learning.
Multidisciplinary Learning	Laboratory investigations integrate concepts from multiple scientific disciplines.	Both support interdisciplinary and holistic learning.
Authentic Assessment	Performance based assessment through laboratory tasks, reports and presentations.	Both recommend competency based and authentic assessment methods.
Teacher as a Facilitator	Teachers guide inquiry instead of merely delivering content.	Both prepare learners with 21 st century competencies.
21 st Century Skills	Develops communication, Collaboration, critical thinking and creativity.	Both emphasize preparing Learners for the demands of the twenty first century.
Promoting Inclusion	IBLI support inclusive and equitable education by creating learning environments that encourage participation, collaboration and meaningful engagement among Diverse groups of learners.	Both helpful in promoting inclusive and equitable education.

4 DISCUSSION

Present study shows that inquiry based laboratory instructions (IBLI) align well conceptually with the principle of National Education Policy 2020. The proposed alignment framework suggests that IBLI can provide a practical context for broad policy goals related to experiential, competency based, learner centered, curiosity driven and inclusive education in science teaching and lab practice. Rather than viewing lab work mainly as completing predetermined procedures, IBLI positions learners as active participants who ask questions, investigate, experiment, gather evidence, analyze, interpret and reflect. This approach aligns with a wider shift from mere content reproduction to meaningful learning and skill development as described in the present study.

5 CONCLUSION

The present conceptual study highlights Inquiry Based Laboratory Instructions (IBLI) as a meaningful pedagogical pathway for translating selected educational aspirations of NEP 2020 into science teaching and learning practices. The review of literature, theoretical perspectives, conceptual foundations and policy principles indicates a strong correspondence between IBLI and the learner centered, experiential, competency based, inquiry oriented and holistic educational approach promoted by NEP 2020, rather than emphasizing rote memorization and predetermined laboratory procedures, IBLI encourages learners to actively participate in questioning, hypothesis formation, experimentation, observation, evidence collection, analysis, explanation, communication and reflection. These inquiry driven processes can facilitate the development of conceptual understanding, scientific process skills, critical thinking, problem solving abilities, creativity, scientific reasoning, laboratory competencies and evidence based argumentation. IBLI may also foster curiosity, motivation, collaboration, scientific self-efficacy and positive attitudes towards learning science. Such characteristics correspond with important priorities of NEP 2020, including experiential learning, competency development, scientific temper, learner centered pedagogy, creativity, collaboration, multidisciplinary learning, authentic assessment and inclusive education. The proposed IBLI and NEP 2020 Alignment Framework connects experiential engagement, scientific inquiry, competency development, collaboration, multidisciplinary learning, authentic assessment, reflection, equity and inclusion with laboratory based science education. However, the effective implementation of IBLI depends on sufficient laboratory infrastructure, trained teachers, professional

development, curriculum flexibility, institutional support, appropriate scaffolding and competency based assessment. Therefore, IBLI should not be regarded as a universal solution but as a promising educational framework that requires empirical validation. Future research should examine its effectiveness, feasibility and adaptability across different subjects, learner groups, and educational contexts in India.

Scope for Future Research

The findings of Aligning Inquiry Based Laboratory Instructions (IBLI) with NEP 2020: A Conceptual Framework for Transforming Science Education suggests diverse potential for future research.

- Study can verify how IBLI training affects teaching skill and pedagogy.
- Effectiveness and applicability of IBLI at primary, secondary, higher and teacher education levels.
- On the basis of some researches on IBLI can find out how it helps marginalized, disadvantage & diverse group of learner.
- In future it will be helpful in integrating virtual laboratories and AI based learning.

Limitations of the Study

This study has some certain limitations that should be considered when interpreting its findings.

- Present study does not involve primary data.
- This study based on only relevant literature, policy provision and educational theories.
- The present study is not empirically examined.
- This study does not measure change in some parameters like students' science competencies, laboratory skills, scientific reasoning etc.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

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