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UNLOCKING YOUNG MINDS: A STUDY ON THE SCIENTIFIC INTELLIGENCE OF SECONDARY SCHOOL STUDENTS THROUGH INQUIRY-BASED LEARNING

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Abstract:

The growing demand for 21st-century skills highlights the critical need to nurture scientific intelligence among school students. Scientific intelligence encompasses reasoning abilities, problem-solving skills, hypothesis testing, and evidence-based thinking. Traditional teaching approaches often neglect the development of these abilities. This study introduces an Inquiry-Based Learning (IBL) program designed to enhance scientific intelligence through experiential learning. 200 students from 10 schools in Pune (five government and five private) were selected through stratified random sampling. The intervention included inquiry-driven activities across key science topics, combined with observation checklists and interviews. Pre- and post-tests assessed changes in scientific intelligence. Results showed a significant increase in scores across both school types, with private school students showing slightly greater gains due to access to better infrastructure. Qualitative feedback supported the effectiveness of the IBL approach. This research demonstrates the potential of constructivist teaching methods in fostering critical thinking and innovation in the classroom.

Key Words: *Inquiry-Based Learning, Scientific Intelligence, Constructivism, Educational Innovation, Secondary Education*

Introduction:

Modern education systems face the challenge of equipping students with skills that extend beyond rote learning. In an era dominated by rapid technological advancements, global connectivity, and a constant flow of information, students must be able to think critically, solve real-world problems, and make informed decisions. Scientific intelligence—defined as the capacity to reason scientifically, test hypotheses, analyze data, and draw conclusions—is central to this goal.

Inquiry-Based Learning (IBL) provides an alternative to traditional instruction by placing students at the center of the learning process. IBL emphasizes curiosity, experimentation, and reflection, allowing students to construct their own knowledge. Rather than simply memorizing facts, students engage in exploring questions, conducting investigations, interpreting results, and applying concepts to new situations.

This research focuses on implementing an IBL program to increase scientific intelligence in secondary school students from government and private schools in Pune city. By comparing the outcomes from diverse school environments, this study provides insights into the broader applicability of IBL and its potential to transform science education.

Review of Literature:

The roots of Inquiry-Based Learning can be traced back to the constructivist theories of Jean Piaget and Lev Vygotsky, who advocated for active student engagement in knowledge construction. Piaget (1952) emphasized that learning is a process whereby students actively create meaning through interaction with their

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environment. Similarly, Vygotsky (1978) highlighted the social dimensions of learning, stressing the importance of collaborative inquiry and scaffolding in cognitive development.

Several empirical studies have demonstrated the effectiveness of IBL in enhancing critical thinking and scientific reasoning. Hmelo-Silver (2004) noted that Problem-Based Learning, a form of inquiry learning, significantly improves students' problem-solving abilities and deeper understanding of content. Further, Bransford et al. (2000) emphasized that learning environments rich in inquiry opportunities enable students to transfer knowledge to novel situations more effectively.

Research by Edelson et al. (1999) also supports the use of inquiry models, suggesting that they foster engagement, motivate students, and enhance academic achievement in science subjects. Best and Kahn (2006) argue that educational interventions grounded in inquiry encourage curiosity and innovation—key traits necessary for scientific literacy.

In the Indian educational context, Dash (2005) asserts the necessity of evolving pedagogical practices to align with global standards, advocating for learner-centered approaches like IBL. Chadha (2007) further emphasizes that fostering cognitive and analytical skills among students is crucial for addressing diverse learning needs and equipping students for real-world challenges.

The cumulative findings from both international and national research underscore the transformative impact of Inquiry-Based Learning on student outcomes. Building upon this strong theoretical and empirical foundation, the present study explores the implementation of an IBL program aimed at enhancing scientific intelligence among secondary school students.

Statement of the Problem:

The persistent reliance on traditional, didactic teaching methods in secondary science education has raised concerns regarding students' cognitive engagement and development of scientific intelligence. Despite curriculum reforms advocating experiential and inquiry-based approaches, classroom practices often remain centered on rote memorization and teacher-led instruction. This disconnect has led to a significant gap in students' ability to apply scientific reasoning, evaluate evidence, and solve real-world problems. The present study seeks to address this issue by investigating the effectiveness of an Inquiry-Based Learning (IBL) program designed specifically to foster scientific intelligence among secondary school students. The core objective is to determine whether structured inquiry processes can enhance students' abilities in reasoning, hypothesis testing, and critical analysis across diverse school environments.

Objectives of the Study:

1. To develop an Inquiry-Based Learning program for secondary students.
2. To assess the effectiveness of the program in enhancing scientific intelligence.
3. To compare the performance of government and private school students.
4. To identify challenges in implementing the IBL program.

Hypotheses:

Based on the study design and objectives, the following hypotheses were formulated:

H_0 (Null Hypothesis): There is no significant difference between the pre-test and post-test scientific intelligence scores of students following the IBL program.

H_1 (Alternative Hypothesis): There is a significant improvement in scientific intelligence scores post implementation of the IBL program.

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Research Questions:

The research was guided by the following core questions: How effective is the Inquiry-Based Learning program in improving the scientific intelligence of secondary school students? Is there a significant difference in the program's impact between government and private school students? What are the implementation challenges encountered by teachers in executing IBL in science classrooms?

Research Methodology

This study employed a mixed-method approach that included both quantitative and qualitative data. The quantitative component involved a quasi-experimental pre-test–post-test design to measure the scientific intelligence scores before and after the intervention. The qualitative component consisted of teacher interviews and classroom observations to understand the learning environment, student engagement, and implementation challenges.

The scientific intelligence test used in the study was developed and validated by the researcher. It included sections on reasoning, problem solving, hypothesis testing, and data interpretation. Observation checklists were used to track student behaviors during activities, and semi-structured interviews with teachers captured feedback on the program's implementation.

Sample and Sampling Technique:

The research sample consisted of 200 secondary students (100 from government schools and 100 from private schools) in Pune city. To ensure proportional and unbiased representation, a stratified random sampling technique was used. Pune city schools were first categorized into two strata: government and private. Five schools were randomly selected from each stratum.

From each school, 20 students were randomly selected across Grade 8 and Grade 9, ensuring gender balance and performance diversity. All participants had prior exposure to basic science concepts.

Procedure:

The research was executed through a methodically structured process that spanned six weeks and engaged multiple stakeholders within the school ecosystem. Initially, an orientation session was organized for school principals, science teachers, and students to introduce the Inquiry-Based Learning (IBL) program. This session was essential for aligning the objectives of the program with the expectations of educators and learners, ensuring that all participants were aware of the pedagogical approach and its anticipated outcomes. Following this, the intervention phase commenced, during which students participated in weekly IBL sessions focused on key scientific themes such as ecosystems, forces and motion, and the human body. These sessions were designed to encourage exploration and foster scientific thinking through a structured inquiry cycle that included formulating questions, hypothesizing, conducting experiments, recording observations, analyzing data, and drawing logical conclusions. Teachers played a critical role in this process by using observation checklists to document student engagement, collaborative efforts, and evidence of critical thinking throughout the learning activities. To quantitatively assess the effectiveness of the IBL program, pre- and post-tests were administered to the students, measuring their development in scientific intelligence. Additionally, at the conclusion of the intervention, semi-structured interviews were conducted with the participating teachers to collect qualitative feedback on the implementation, student response, and perceived challenges. This comprehensive procedure ensured that the study captured both the measurable impacts and the contextual dynamics of implementing IBL in secondary science education.

Analysis of Data:

The analysis of data was carried out using both descriptive and inferential statistics to determine the

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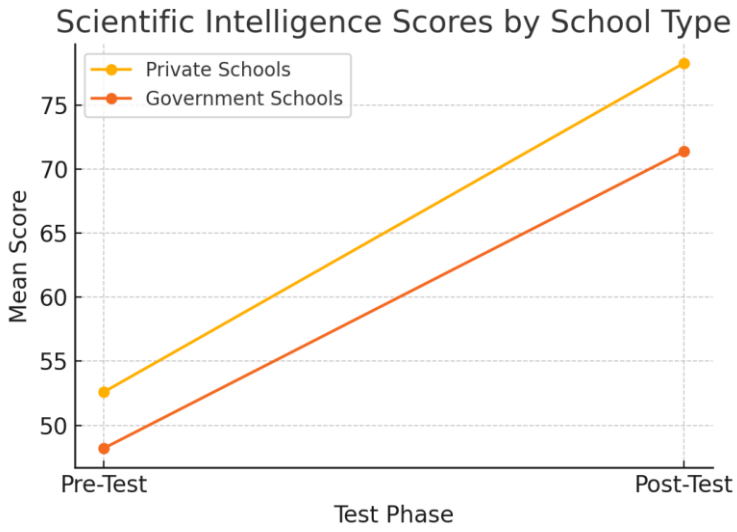
effectiveness of the Inquiry-Based Learning (IBL) program. Pre-test and post-test scores of scientific intelligence were recorded for all 200 participants across government and private school categories. The mean scores, standard deviations, and paired sample t-tests were computed to assess the statistical significance of the observed differences. The findings revealed that students in both groups showed marked improvements in their post-test scores following the intervention. Notably, the average post-test score of students from private schools increased from 52.6 to 78.3, while the scores for government school students improved from 48.2 to 71.4. These results underscore the positive impact of the IBL approach in enhancing scientific intelligence regardless of the school type.

Results and Discussion:



School Type	Pre-Test Score	Post-Test Score
Private Schools	52.6	78.3
Government Schools	48.2	71.4

Interpretation:

The analysis of pre- and post-test scores across both government and private school groups reveals a significant improvement in students' scientific intelligence after the implementation of the Inquiry-Based Learning (IBL) program. Students demonstrated greater proficiency in core areas such as observation, data interpretation, logical reasoning, and hypothesis formulation.

The comparative results suggest that while private school students exhibited a marginally higher level of improvement—possibly due to access to advanced resources like laboratories and digital tools—the government school students showed equally noteworthy progress. This supports the idea that IBL is not limited by infrastructure but thrives on pedagogical design and teacher facilitation.

Qualitative feedback from participating teachers indicated increased levels of student engagement, deeper curiosity, and better conceptual understanding. Teachers noted that students asked more questions, worked collaboratively with peers, and were more confident during class presentations. Although some challenges such as limited time and need for teacher training were identified, the positive impact of the IBL methodology on student outcomes was evident.

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These findings affirm that scientific intelligence is not an innate trait but a skill that can be nurtured through structured inquiry and experiential learning, across diverse educational contexts.

Conclusion:

This research successfully developed and implemented an Inquiry-Based Learning program aimed at enhancing scientific intelligence among secondary school students. The study's findings confirm that IBL is an effective and transformative approach that can significantly improve students' ability to reason, analyze, and solve problems in a scientific context.

Students from both government and private schools benefited from the program, demonstrating that inquiry-driven education is not only effective but also inclusive. By engaging students in real-world problem-solving activities, the IBL approach fostered critical thinking, creativity, and a genuine interest in science.

To make this model sustainable and scalable, there is a pressing need to integrate IBL into the mainstream curriculum. Policymakers and school administrators must support this transition through investment in teacher training, infrastructural improvements, and curriculum flexibility.

Ultimately, if we aim to develop a scientifically literate and innovative generation, then pedagogical strategies like Inquiry-Based Learning must become the foundation of science education in schools.

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