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"EFFECT OF PROBLEM BASED LEARNING ON ACHIEVEMENT IN SCIENCE OF SECONDARY SCHOOL STUDENTS"

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Abstract

The aim of this study is the investigation of the "Effect of Problem Based Learning on achievement in science of secondary school students" of 10th standard in Bareilly district. Quasi-experimental design was employed for the study. It is a Research which is pre- test and post-test with Control group design was used. The sample of 120 students (Experimental, N= 60; Control, N= 60) for the study is selected from the 10th class students of Aided Secondary schools of District Bareilly, UP, India. it was performed in academic year session 2023-24. The data of the research has been collected by the Science Achievement test (SAT) developed by Ali Imam & Gyan Pratap Singh. The study revealed that there is significant difference in the achievement in science of experimental and control groups. Achievement in Science of experimental groups (mean=42.17) is significantly better than the control group (mean=35.87). The control group was taught with the traditional lecture method whiles the experimental group received instruction with PBL method . Independent T- test was used for the analysis and interpretation of data. Results showed that there was significant difference in science achievement of students between control and the experimental group while there was no significant differences in the before the study. The results show that Problem Based Learning is an effective way for to teach science subject at secondary level.

Keywords: Secondary School Students, Achievement in Science, Problem-Based Learning (PBL).

1. INTRODUCTION - The 21st century has marked a paradigm shift in education, moving from conventional rote learning to more student-centric and inquiry-based approaches. In this context, Problem-Based Learning (PBL) has emerged as a powerful pedagogical strategy designed to enhance critical thinking, collaboration, and content understanding. In the teaching of science at the secondary level, where cognitive development and conceptual understanding are crucial, PBL offers an interactive, student-driven alternative to traditional instruction. This study is premised on the assertion that PBL can significantly influence students' achievement in science by promoting active engagement, contextual learning, and real-life problem-solving skills. In India and globally, educators and researchers are increasingly focusing on aligning science education with constructivist principles, where learners build knowledge through meaningful experiences, and PBL serves as an effective medium for achieving this end.

The secondary stage of education is a crucial period in students' academic journey as it lays the foundation for higher studies and career development. Science, being a core subject at this stage, demands the development of higher-order thinking skills, conceptual clarity, and an inquisitive mindset. However, traditional lecture-based methods often fall short of making science learning engaging and relevant. Students frequently memorise scientific facts without understanding their applications or the underlying principles. Consequently, their academic achievement remains superficial and exam-oriented, lacking depth and practical significance. In contrast, PBL transforms the learning environment by introducing real-world problems that require investigation, discussion, and the application of scientific concepts. This shift not only increases students' motivation and interest but also enhances their understanding, retention, and ability to transfer knowledge across contexts.

Problem-Based Learning is rooted in the constructivist theory of learning, particularly in the work of educational psychologists like Jean Piaget, Jerome Bruner, and Lev Vygotsky. These theorists emphasised the importance of active participation, social interaction, and scaffolding learning in cognitive development. PBL involves presenting students with complex, ill-structured problems that mimic real-life scenarios. Working in small groups, students explore the problem, identify what they need to learn, and seek out necessary information collaboratively. The teacher acts as a facilitator, guiding students through the learning process rather than delivering direct instruction. This method not only fosters deeper understanding but also builds essential life skills such as teamwork, communication, self-regulation, and decision-making.

Numerous empirical studies support the positive impact of PBL on students' academic achievement in science. Research conducted by **Dochy et al. (2003)** found that students engaged in PBL demonstrated better long-term retention of knowledge and performed well on application-based assessments. Similarly, a study by **Gallagher, Stepien, and Rosenthal (1992)** showed that secondary school students who experienced PBL in science exhibited higher achievement scores compared to their peers in traditional classrooms. These findings underscore the effectiveness of PBL in fostering deep learning and conceptual understanding, which are essential for success in science education.

In the Indian context, the National Education Policy **(NEP) 2020** has strongly advocated for experiential and inquiry-based learning approaches in schools. It encourages pedagogical innovations like PBL that aim to cultivate scientific temper and analytical thinking among students6. Despite such policy endorsements, the adoption of PBL in Indian schools remains limited due to systemic challenges such as rigid curricula, teacher preparedness, and assessment constraints. However, several experimental initiatives and pilot programs in different states have demonstrated encouraging results. for instance, a PBL intervention program implemented in Karnataka schools led to significant improvement in students' science achievement and engagement levels.

Another critical aspect of this study is its focus on student achievement as an outcome measure. Achievement in science is typically assessed through tests and examinations that measure recall, understanding, application, and analytical abilities. PBL, by design, targets these higher levels of cognitive processing. When students solve authentic problems, they engage in hypothesis formation, data collection, experimentation, and argumentation – all of which are central to scientific inquiry. Consequently, students develop a more robust and transferable understanding of scientific principles, leading to better academic performance.

2. NEED AND SIGNIFICANCE OF THE STUDY –

In the modern educational landscape, where the focus is gradually shifting from rote memorisation to critical thinking and problem-solving, the relevance of innovative pedagogical strategies has increased significantly. Among them, Problem-Based Learning (PBL) has emerged as one of the most effective student-centred approaches aimed at fostering inquiry-based learning, creativity, and a deep understanding of content, especially in subjects like science that demand both conceptual clarity and

practical application. The study titled "Effect of Problem-Based Learning on Achievement in Science of Secondary School Students" is necessitated by the growing need to equip learners with the skills required to face complex real-world problems. In traditional science classrooms, students are often passive recipients of information, memorising facts and formulas without fully understanding the underlying scientific principles or their applicability in everyday life. This results in a superficial understanding of science, which not only hampers academic achievement but also diminishes interest and motivation toward the subject. PBL addresses this gap by placing students in the active role of problem-solvers confronted with real-life scenarios, thereby stimulating higher order thinking, collaboration, research aptitude, and self-directed learning. In the context of secondary education, where students are at a critical stage of cognitive and emotional development, it becomes even more important to instill a scientific temper and curiosity. Science education at this level forms the foundation for higher studies and careers in STEM fields. Therefore, implementing teaching methods that enhance understanding and achievement is crucial.

The National Education Policy (NEP) 2020 and other educational reforms worldwide have advocated for inquiry-based and experiential learning strategies, and PBL aligns perfectly with these objectives. This study becomes significant in analysing whether PBL can result in better academic achievement in science compared to traditional methods. It is also necessary to identify how PBL impacts students' attitudes towards science, their motivation to learn, and their ability to retain and apply knowledge. Moreover, in a country like India, where science performance among students is often inconsistent and where teaching is still heavily textbook-oriented, this study holds great significance in promoting learner engagement and scientific literacy. It also becomes relevant for educators and policymakers seeking to bridge the gap between theoretical instruction and practical learning outcomes. Another pressing reason to conduct this study is the demand for lifelong learners who are not only knowledgeable but also possess problem-solving abilities, decision-making skills, and teamwork competencies that are naturally fostered through PBL.

In a rapidly changing scientific and technological world, secondary students must be equipped to think critically and adapt to new challenges. PBL, by its very design, encourages students to analyse complex situations, search for information, and synthesise knowledge, which directly contributes to academic success and intellectual growth. Additionally, as the global academic community continues to emphasise the importance of assessment for learning rather than mere assessment of learning, the use

of PBL could redefine evaluation strategies in science education. This study also explores the feasibility of implementing PBL within the constraints of school curricula, teacher competencies, and available resources. It aims to inform teachers about the benefits of shifting their instructional approach, and may serve as a guide for teacher training programs aimed at capacity building in innovative methodologies. The study's findings could also support curriculum developers in integrating problem-based tasks within textbooks and classroom activities. Furthermore, this research becomes vital for understanding student diversity in classrooms. Secondary school students vary widely in terms of learning styles, prior knowledge, motivation, and socio-economic backgrounds. PBL provides a flexible structure where students can learn at their own pace and contribute meaningfully to group discussions, thereby promoting inclusivity and reducing achievement gaps. For students who find science difficult or abstract, problem- based learning offers a contextual and applied framework that demystifies concepts and promotes meaningful engagement. By making science relatable and solution-oriented, PBL can transform student perception and performance. Additionally, this study is important in the digital age where students are more connected to real-world issues and possess access to multiple sources of information.

PBL nurtures digital literacy, research skills, and responsible use of online tools to investigate problems and propose solutions. The study will also investigate how technology can be integrated within the PBL framework to enhance science learning. Moreover, the significance of this research lies in its potential to serve as an empirical base for future academic explorations. By analysing quantitative data on students' achievement and comparing it between traditional and PBL methods, the study provides evidence-based recommendations that can shape educational policies and classroom practices. It fills a crucial research gap in the Indian and global context, where, despite numerous theoretical endorsements of PBL, empirical studies on its effectiveness in science education at the secondary level remain limited. Additionally, this research holds value in post-pandemic education, where students need to become self-reliant learners due to increasing hybrid and online modes of learning. PBL, with its emphasis on autonomy and inquiry, fits well within these new learning ecosystems.

In conclusion, this study is both timely and necessary. It explores the extent to which PBL can revolutionise science education by enhancing academic achievement and developing essential 21st century skills among secondary school students. It informs teachers, school leaders, curriculum designers, and policymakers about the practical implications of adopting a problem-based instructional strategy. The research aims not

just to compare outcomes but to encourage a mindset shift in how science is taught and learned in schools. As the world continues to face scientific challenges like climate change, health crises, and technological disruptions, the need for scientifically literate, critical thinkers has never been greater. This study contributes meaningfully to this goal by investigating a strategy that promises to make science learning more engaging, relevant, and effective for future generations.

3. REVIEW OF RELATED LITERATURE

- **Ciftci, S. & Tatar, N. (2020)** Effectiveness of problem-based learning on students' academic achievement in science education: A meta-analysis study. The meta-analysis covered over 50 studies and revealed that PBL has a significant positive effect on students' academic achievement in science. The impact was higher at the secondary level than at the primary or tertiary levels.
- **Lee, Y. & Park, M. (2021).** Problem-Based Learning in Secondary School Science: Effects on Motivation and Academic Achievement, PBL significantly improved student engagement and learning outcomes in science subjects. The study indicated higher conceptual understanding and long-term retention among students in PBL settings compared to traditional instruction.
- **Sharma, A. & Gupta, R. (2021).** Influence of Problem-Based Learning Approach on Academic Performance of Grade 10 Science Students in Indian Schools, An experimental study showed that the experimental group taught through PBL performed significantly better in biology and physics tests than the control group.
- **Akhter, N. et al. (2022).** Impact of Problem-Based Learning on the Science Achievement of Secondary School Students in Pakistan. Students exposed to PBL over 10 weeks showed improvements in critical thinking, problem solving skills, and science test scores.
- **Zhang, J. & Chen, L. (2022**). Exploring Cognitive Load in Problem-Based Learning in Science Classrooms. Though PBL enhances achievement, the study found it may initially increase cognitive load, especially for low achieving students. However, with scaffolder support, long-term gains were positive.
- **Thomas, A. & Francis, K. (2023).** Student Perceptions of Problem-Based Learning and Its Impact on Academic Achievement in Science, A mixed methods study found that students appreciated PBL for its real-life relevance and teamwork, reporting better grades and interest in science as a result.
- **Banerjee, P. (2023).** Effect of Problem-Based Teaching Methods on the Science Learning of Secondary School Students. This quasi-experimental study showed

significant improvement in physics achievement scores among students taught via PBL versus traditional methods.

- **Wang, H. & Liu, X. (2024).** Gamified Problem-Based Learning and Science Achievement among Secondary Students. Combining gamification with PBL led to even greater gains in student achievement and engagement.
- **Rahman, S. et al. (2024).** Comparative Study of PBL and Traditional Methods on the Achievement of 9th Grade Science Students, The experimental group using PBL showed 25% higher post-test scores in general science than the traditional group.
- **Kumari, M. & Patel, D. (2025**). Role of Teacher Facilitation in Effective Implementation of PBL in Science Classrooms. Effective teacher facilitation, feedback, and question framing significantly influenced the success of PBL in improving student achievement.

3. STATEMENT OF THE PROBLEM- ***"EFFECT OF PROBLEM BASED LEARNING ON ACHIEVEMENT IN SCIENCE OF SECONDARY SCHOOL STUDENTS"***

4. VARIABLES-

INDEPENDENT VARIABLE – PBL (Problem Based Learning), conventional method of teaching

DEPENDENT VARIABLE- Achievement in science (SAT)

5. OPERATIONALLY DEFINITION OF THE VARIABLE-

*** PROBLEM BASED LEARNING**- Problem-based learning (PBL) is a pedagogical approach based on recent advances in cognitive science research on human learning. PBL as a student-centred pedagogical learning involves students put into smaller group to discuss a challenging problem with the aim of finding solution to the problem.

* **ACHIEVEMENT IN SCIENCE**- scientific achievement can be defined as knowledge gained or skills developed as a result of studying Science as a subject. scores on science achievement test SAT of the students is considered as achievement in science in this study

*** SECONDARY SCHOOL STUDENTS**- 10TH Standard students who are enrolled in up board secondary school of Bareilly in session 2023-24 are secondary school students in the study.

6. OBJECTIVES OF THE STUDY-1 To study the effect of Problem Based Learning on Achievement in science of secondary school students.

7. HYPOTHESIS OF THE STUDY- **H0**1: There is no significance difference between experimental and control groups in the achievement in science of secondary school students.

8. METHOD- Quasi-Experimental method of research with randomized groups pre-test and post-test control group design was used. In the study the independent variable were "Problem Based Learning Method" for experimental group and Traditional Method for control group. The dependent variables in the groups were the same and it was "science achievement test (SAT).

9. SAMPLE - The sample of 120 students (Experimental, N=60; Control, N=60) for the study is selected from the 10th class students of Aided Secondary schools of District Bareilly, UP, India. it was performed in academic year session 2023-24.

10. TOOLS –

PBL model lesson plan – prepared by researcher based on 10th standard science book.

Science Achievement Test (SAT)- Developed by Ali Imam & Gyan Pratap Singh NPC Agra.

11. Analysis and Interpretation of data :

Hypothesis 1 : H0 1: There is no significance difference between experimental and control groups in the achievement in science of secondary school students.

TABLE 1 : Pre- test score of experimental and control group on science achievement test (SAT) and result of t-Test for Independent group.

Group	N	Mean	SD	DF	t-Ratio	Significance result
Experimental	60	30.72	11.30	118	0.67	*Not significant At 0.05 level
Control	60	29.40	10.25			

***Not significant at 0.05 level of significance**

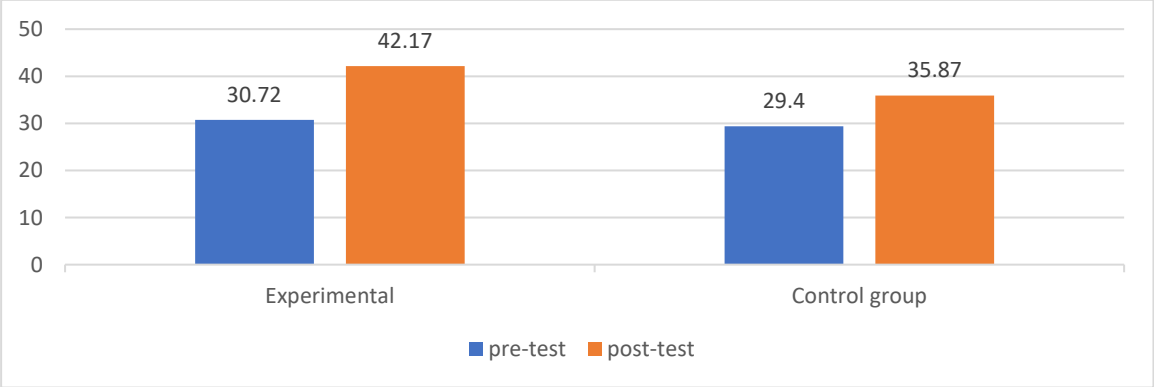
The above table-1 compares the mean achievement scores in science between the experimental and control groups on pre- test. The mean score of the experimental group is 30.72 and SD is 11.30, while the mean score of the control group is 29.40 and SD is 10.25. The calculated t-value is 0.67. the corresponding t- table value is 1.98 . t-calculate value is less than t-table value with 118 df and 0.05 level of significance (t-calculated value < t-table value). the result is Statistically not significant, which means there is no significant difference in science achievement between the experimental and control groups before the study.

Effect of Problem Based Learning on Achievement in Science: The t-ratio was calculated to compare the achievement in science of the groups taught using the problem-based learning approach and conventional teaching, and the values are shown in table 2 below.

Table 2. Comparison of mean science achievement test scores on post -test of experimental and control group.

GROUP	N	MEAN	SD	df	t-ratio	significance result
Experimental	60	42.17	10.65	118	3.38	*Significant at 0.05 level
Control	60	35.87	9.76			

***Significant at 0.05 level of significance**



Graphical representation of mean score between experimental and control group on science achievement test (SAT)

The above table-2 compares the mean achievement scores in science between the experimental and control groups. The mean score of the experimental group is 42.17 and SD is 10.65 , while the mean score of the control group is 35.87 and SD is 9.76 . The calculated t-value is 3.38 and t-table value is 1.98 with 118 DF. t-calculated is greater than t-table value at significance level of 0.05. so. the result is Statistically significant, which means there is significant difference in science achievement between the experimental and control groups. Therefore, the null hypothesis is rejected, and it can be interpreted that the use of the intervention (e.g., problem-based learning) in experimental group produce a statistically significant improvement in science achievement compared to the traditional method used in the control group. there was a

significant difference in achievement scores between students exposed to the use of PBL instructional approach and those exposed to the traditional instructional approach of teaching science.

12. Conclusion

Based on the statistical analysis and interpretation of the data presented in Table 2, it can be concluded that There is significant difference between the science achievement scores of students in the experimental group and those in the control group. The obtained t-value (3.58) is significant at 0.05 level of significance. Hence, the null hypothesis stating that "There is no significant difference between experimental and control groups in the achievement in science of secondary school students" is rejected. This indicates that the teaching strategy PBL applied to the experimental group lead to a measurable improvement in science achievement when compared to traditional teaching methods used in the control group.

13. Result

The null hypothesis is rejected. There is a significant difference in science achievement between the experimental and control groups at the 0.05 level of significance. Problem based learning (PBL) had a positive effect on achievement in science of secondary school students.

14. Educational Implications: The present study's findings revealed that the problem-based learning PBL improves student achievement in science subject, so it is recommended that every science teacher of secondary school use this approach when teaching for better science achievement.

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