SHIKSHA SAMVAD
International Open Access Peer-Reviewed & Refereed
Journal of Multidisciplinary Research
ISSN: 2584-0983 (Online)
Volume-02, Issue-03, March- 2025
www.shikshasamvad.com

Effect of problem-based learning on problem solving skills of secondary school students

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Abstract:

The aim of this study is the investigation of the effect of Problem based learning (PBL) on the Problem-Solving skills of prospective secondary school students of 10th standard in Bareilly district. Quasi-experimental design was employed for the study. It is 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 Problem-Solving Ability test developed by L.N. Dubey. The study revealed that there is significant difference in the Problem-Solving Skills of experimental and control groups. Problem Solving Skills of experimental groups (mean=13.63) is significantly bettaer than the control group (mean=10.89). The control group was taught with the traditional lecture method while the experimental group received instruction with PBL. Independent t- test was used for the data analysis and interpretation. Results showed that there was significant difference in problem solving skills of students between control and the experimental group while there was no significant differences in the before the study. The results show that PBL is an effective way for to problem solving skills at secondary level.

Keywords: *Problem Solving Skills, Problem-Based learning (PBL), Secondary School Students.*

1 INTRODUCTION –

In the modern education, the demand for learners who can adapt, analyse, evaluate, and respond to rapidly changing situations is more pressing than ever. Traditional teacher-centred pedagogies have often emphasized rote memorization and passive learning, which may not be sufficient to equip students with the critical life skills necessary in the 21st century. One such essential life skill is problem-solving, a cognitive process crucial for navigating both academic and real-life challenges. In response to this educational necessity, innovative strategies such as Problem-Based Learning (PBL) have gained momentum in global educational discourse. PBL is a student-centred instructional method in which students learn through the experience of solving open-ended problems. It fosters collaboration, self-directed learning, and the practical application of knowledge. This paradigm shift in instructional strategy plays a pivotal role in enhancing the problem-solving skills of secondary school students—preparing them to face real-world complexities with analytical aptitude and strategic thinking.

Problem-based learning (PBL) has its roots in medical education, particularly at **McMaster University** in Canada during the 1960s. Its success in fostering deep learning among medical students inspired its adoption across other disciplines and educational levels. The foundational idea behind PBL is that students are presented with real-world problems before they have received formal instruction in the relevant concepts. This encourages them to engage in self-directed research, critical discussion, hypothesis testing, and practical application—components that mirror the processes used by professionals in authentic settings. Consequently, this educational model aligns strongly with constructivist theories of learning, which argue that learners actively construct their knowledge through experience rather than passively receiving it.

Secondary education is a critical stage in a student's academic journey, representing a transition between foundational education and higher-order academic or vocational pursuits. At this level, students are expected to develop cognitive skills that are not only foundational for academic achievement but also essential for responsible citizenship and personal development. Problem solving is one of those higher-order thinking skills that underpin intellectual engagement, innovation, and success in diverse spheres of life. Unfortunately, research has often indicated that traditional methods of instruction in secondary schools do not sufficiently encourage the development of problem-solving abilities, largely because these methods emphasize the acquisition of factual knowledge over the application of knowledge in novel contexts1

PBL emerges as a remedy to this pedagogical limitation. It introduces a dynamic and active learning environment where learners are not mere recipients of information but active constructors of knowledge. Students work in teams, tackle real-world problems, and engage

in self-directed inquiry. Such a learning environment naturally fosters a deeper understanding of subject content and enhances transferable skills like critical thinking, communication, collaboration, and especially problem-solving. The collaborative aspect of PBL ensures that students develop interpersonal skills as they work with peers to understand problems, divide tasks, evaluate solutions, and reflect on outcomes. These social interactions within a PBL setting are not only academically enriching but also enhance emotional intelligence and group decision-making skills.

Another strength of PBL lies in its interdisciplinary nature. Real-life problems are not confined to the boundaries of individual school subjects. For instance, a problem related to water pollution involves knowledge from chemistry, environmental science, geography, social studies, and even economics. When secondary school students engage in PBL, they learn to synthesize information from multiple disciplines to arrive at comprehensive solutions. This mimics real-world problem-solving scenarios, where a multidisciplinary approach is often necessary. As such, PBL does not just enhance problem-solving skills in a narrow academic sense but broadens students' cognitive horizons and improves their ability to view challenges from multiple perspectives.

Additionally, PBL enhances motivation and engagement. When students see the relevance of what they are learning to real-life situations, their intrinsic motivation to learn increases. This sense of purpose leads to deeper engagement with the subject matter and a more persistent approach to problem solving. Motivation is a critical factor in student success, and when it is nurtured through engaging and relevant pedagogies like PBL, it results in improved learning outcomes. Secondary school students, who are often at a stage of questioning and curiosity, respond well to PBL as it allows them to explore issues that are meaningful to them and their communities.

Technological advancements have further enabled the implementation of PBL in secondary classrooms. With access to digital tools, the internet, and multimedia resources, students can research problems, communicate with experts, simulate experiments, and present findings in innovative ways. Technology also facilitates personalized learning, allowing students to pursue solutions at their own pace and according to their learning styles. These digital enhancements not only support the problem-solving process but also equip students with digital literacy skills essential for the 21st century.

A growing body of research supports the positive impact of PBL on problem-solving skills. A study by **Hmelo-Silver (2004)** revealed that students engaged in PBL showed superior problem analysis and hypothesis generation abilities compared to their peers in traditional classrooms. Similarly, research conducted by **Belland, Glazewski, and Ertmer (2009)** indicated that PBL significantly improved students' problem-solving strategies, particularly in science education.

In the context of the Indian education system, which has traditionally emphasized examination-driven learning, the adoption of PBL poses both challenges and opportunities. The National Education Policy (NEP) 2020 advocates for experiential learning, critical thinking, and competency-based assessments—all of which align with the principles of PBL. Incorporating PBL into secondary education aligns with this vision and can serve as a catalyst for transforming Indian classrooms into spaces of inquiry, creativity, and holistic development. Given the demographic advantage India holds, equipping its youth with robust problem-solving skills through PBL can have far-reaching implications for the country's socio-economic development9.

2 NEED AND SIGNIFICANCE OF THE STUDY –

In the contemporary educational landscape, the focus has shifted from rote memorization and traditional teacher-centric methods to student-centred approaches that foster critical thinking, creativity, and lifelong learning. Among these progressive pedagogies, Problem-Based Learning (PBL) has emerged as a powerful instructional strategy that not only enhances conceptual understanding but also develops essential life skills such as problem-solving, decision-making, collaboration, and self-directed learning. The need to explore the effect of Problem-Based Learning on the problem-solving skills of secondary school students is rooted in the increasing demand for education systems to prepare learners who can effectively respond to real-world challenges. Traditional classroom practices, where teachers act as the sole dispensers of knowledge and students passively receive information, often fail to stimulate cognitive engagement and higher-order thinking. In contrast, PBL situates students in the context of meaningful, complex, and authentic problems that require them to explore, inquire, analyse, and derive solutions. This method empowers students to take ownership of their learning, apply interdisciplinary knowledge, and reflect on their thought processes. In the context of secondary education, where students undergo a critical phase of intellectual and emotional development, cultivating problem-solving abilities is of paramount importance. These skills are not only essential for academic success but are also foundational for personal growth, employability, and responsible citizenship in the 21st-century knowledge society.

Furthermore, the relevance of this study extends beyond classroom implications. In a rapidly evolving global economy driven by technology, innovation, and complex problem scenarios, employers increasingly value individuals who can think critically, adapt swiftly, and solve problems efficiently. If secondary school students are trained through methodologies like PBL, they are more likely to become competent individuals capable of meeting future career challenges. In addition, societal progress depends on citizens who can analyse issues logically, make informed decisions, and contribute constructively. Thus, developing problem-solving skills through education has far-reaching implications for

nation-building and sustainable development. The study also aligns with the principles outlined in the National Education Policy (NEP) 2020, which emphasizes experiential learning, competency-based education, and the holistic development of learners. Conducting this research not only validates the pedagogical effectiveness of PBL but also provides insights into tailoring it to diverse learner needs and contexts.

Another dimension underscoring the need for this study is the diversity of learning styles and cognitive abilities among secondary school students. PBL accommodates different types of learners by offering multiple entry points to learning and encouraging exploration in various directions. For students who may struggle with abstract concepts in traditional settings, PBL provides concrete, real-life contexts that make learning meaningful and accessible. This adaptability makes it an inclusive approach that caters to a broad spectrum of students, thereby enhancing equity in education. Moreover, in an age where students are increasingly exposed to distractions such as digital media, maintaining sustained cognitive engagement is a challenge. PBL, with its active, hands-on, and collaborative nature, captures student interest and promotes intrinsic motivation. This leads to deeper learning and better retention of knowledge. Therefore, examining the effect of PBL on problem-solving skills is not just an academic inquiry but a strategic exploration of how to make education more engaging, effective, and relevant.

From a research perspective, this study is essential as it contributes to the growing body of educational research that evaluates the impact of innovative teaching methodologies. While several studies have acknowledged the theoretical benefits of PBL, there is a need for context-specific empirical research, especially in the Indian secondary school context. Educational settings in India are marked by diversity in terms of student backgrounds, resource availability, and teaching practices. A comprehensive study on the effect of PBL in such a scenario can offer context-sensitive insights and practical recommendations. It can identify the strengths and challenges of implementing PBL in real classrooms, the readiness of teachers and students, and the structural support required for its success. These findings can inform teacher training programs, curriculum design, and policy formulation. They can also inspire future research into other aspects of learner development influenced by PBL, such as creativity, self-regulation, and emotional intelligence.

Lastly, the significance of this study lies in its potential to shift educational focus from mere content delivery to holistic skill development. In an age marked by rapid technological changes, socio-economic uncertainties, and complex global issues, equipping students with problem-solving skills is not optional—it is essential. Problem-Based Learning is not merely a teaching technique but a transformative pedagogical philosophy that prepares learners to become thinkers, innovators, and problem-solvers. By studying its impact on secondary school students, we can gain valuable insights into nurturing a generation that is not only

academically competent but also emotionally resilient, socially aware, and future-ready. Thus, the present research has both theoretical and practical significance, and its findings can contribute meaningfully to enhancing the quality, relevance, and inclusivity of secondary education. It emphasizes the urgent need to innovate educational practices and demonstrates the profound benefits of embedding real-world problem-solving at the core of teaching and learning processes.

3 REVIEW OF RELATED LITERATURE –

- **Savery, J. R. (2020)** reiterated that PBL aligns with constructivist learning theories, encouraging students to build their own understanding through real life problems. According to Savery, students exposed to PBL develop improved cognitive engagement and are better able to apply knowledge in diverse contexts. The study highlighted the success of PBL in enhancing skills like analysis, interpretation, and solution generation in secondary classrooms.
- **Almeida & Torres (2021)** conducted a meta-analysis of 25 studies from 2010–2020. Though some were outside the 2020–2025 scope, this meta analysis extended into current research. The study found that PBL had a medium to large effect size on students' problem-solving and cognitive flexibility.
- **Maharjan & Dahal (2021)** conducted a quasi-experimental study in Nepal involving 8th-grade science students. The experimental group, taught through PBL, outperformed the control group in problem-solving tests. The researchers concluded that PBL significantly improves analytical and critical thinking capabilities in students.
- **Patel & Sharma (2022)** compared PBL with traditional lecture methods in teaching mathematics to secondary students in Gujarat, India. Their findings revealed a statistically significant increase in problem-solving performance among students taught through PBL.
- **Thomas & Elangovan (2022)** emphasized the importance of teacher training for successful implementation of PBL. Their study showed that when teachers are well-trained in PBL pedagogy, students' problem-solving skills improved more significantly.
- **Chen et al. (2023)** explored the effects of PBL in physics education among Chinese secondary students. The study reported improvements in both conceptual understanding and problem-solving skills, particularly in application-based questions. The collaborative nature of PBL was also found to improve communication and reasoning skills.
- **Kumar & Rao (2024)** examined the use of digital tools in problem-based learning environments in Indian secondary schools. Their study revealed that integrating PBL with ICT tools enhanced not only students' engagement but also their problem-solving and independent learning skills.

• **Sulaiman et al. (2025)** tracked a cohort of students over three years to examine the long-term benefits of PBL. They found that students retained higher-order thinking and problem-solving skills even after the PBL sessions concluded, indicating lasting cognitive gains.

4 STATEMENT OF THE PROBLEM-

"EFFECT OF PROBLEM BASED LEARNING ON PROBLEM SOLVING SKILLS OF SECONDARY SCHOOL STUDENTS."

5 VARIABLE-

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

• DEPENDENT VARIABLE- Problem Solving Skills (PSS)

6 OPERATIONALLY DEFINITION OF THE VARIABLE-

• PROBLEM BASED LEARNING: Problem-Based Learning (PBL) enhances critical thinking, problem-solving, collaboration, and self directed learning skills by engaging students in real-life problems. It shifts the focus from rote memorization to active inquiry, fostering deeper understanding and long-term retention of knowledge across various academic disciplines.

• PROBLEM SOLVING SKILLS: Problem-solving skills refer to the ability to identify issues, analyse situations, develop solutions, and implement effective actions to overcome challenges. The score achieved by students on problem solving ability test is considered as problem solving skills of students in this study.

• SECONDARY SCHOOL STUDENTS: Secondary school students are learners typically aged between 11 to 18 years who are enrolled in 10th standard secondary school of Bareilly district in session 2023-24

7 OBJECTIVES OF THE STUDY-

1 To study the effect of Problem Based learning on Problem Solving Skills of secondary school students.

8 HYPOTHESIS OF THE STUDY-

H01: There is no significance difference between experimental and control groups in the Problem Solving Skills of secondary school students.

9 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 "Problem Solving Skills test (PSS).

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

11 TOOLS –

- PBL model lesson plan – prepared by researcher based on 10th standard mathematics book.
- Problem Solving Ability -Test developed by ***L.N. Dubey*** National Psychological Corporation Agra.

12 Analysis and Interpretation of data :

Hypothesis 1 : H01: There is no significance difference between experimental and control groups in the problem solving skills of secondary school students.

Effect of Problem Based Learning on problem solving skills: The t-ratio was calculated to compare the problem solving skills of the groups taught using the problem-based learning approach and conventional teaching, and the values are shown in table 1 below and Table 2: Significance of Difference in Problem Solving Skills (Gain Score) of the Groups Taught Through Problem-based learning Approach and Conventional Teaching.

Table 1 pre- test score of experimental and control group students' result of t-test for independent group.

Group	N	Mean	SD	DF	t-Ratio	significance
Experimental	60	9.87	3.78	118	**1.69**	***Not significant at 0.05 level**
Control	60	8.65	4.10			

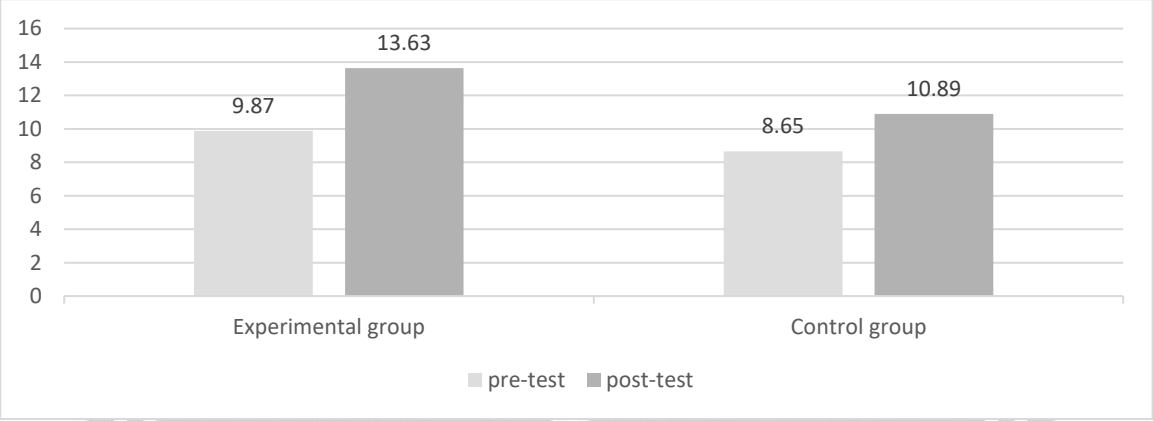
**** Not Significant at 0.05 level of significance***

The above table-1 compares the mean scores on problem solving ability test between the experimental and control groups on pre- test. The mean score of the experimental group is 9.87 and SD is 3.78, while the mean score of the control group is 8.65 and SD is 8.65. The calculated t-value is 1.69 the corresponding t- table value is 1.98 . t- calculate value is less than t-table value with 118 DF (t-calculated value < t-table value). the result is Statistically not significant, which means there is no significant difference in problem solving skills between the experimental and control groups before the study.

Table 2. t- test for post-test score on problem solving ability test of experimental and control group students

Group	N	Mean	SD	DF	t-ratio	Significance result
Experimental	60	13.63	4.57	118	**3.52**	***significant At 0.05 level**
Control	60	10.89	3.92			

*** Significant at 0.05 level of significance**



Graphical representation for pre-test and post test mean score on problem solving ability test

The above table-2 compares the mean scores in Problem Based Learning between the experimental and control groups. The mean score of the experimental group is 13.63 and SD is 4.57, while the mean score of the control group is 10.89 and SD is 3.92.The calculated t-value is 3.52 and the corresponding t-table -value is 1.98, the t-calculated value is greater than t-table value so the result is Statistically significant, which means there is significant difference in problem solving ability 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) produce a statistically significant improvement in experimental group compared to the traditional method used in the control group. there was a significant difference in problem solving skill between students exposed to the use of PBL instructional approach and those exposed to the traditional instructional approach.

13. 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 Problem Solving Ability scores

of students in the experimental group and those in the control group. The obtained t-value (3.52) 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 Problem Solving Skills of secondary school students" is rejected. This indicates that the teaching strategy PBL applied to the experimental group lead to a measurable improvement in problem solving skill when compared to traditional teaching methods used in the control group.

14. Result

The null hypothesis is rejected. There is significant difference in problem solving skills between the experimental and control groups at the 0.05 level of significance.

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

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An Online Quarterly Multi-Disciplinary
Peer-Reviewed or Refereed Research Journal
ISSN: **2584-0983 (Online)** Impact-Factor, **RPRI-3.87**
Volume-02, Issue-03, March- 2025
www.shikshasamvad.com
Certificate Number-March-2025/18

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"Effect of problem-based learning on problem solving skills of secondary school students"

Published in 'Shiksha Samvad' Peer-Reviewed and Refereed Research Journal and E-ISSN: 2584-0983(Online), Volume-02, Issue-03, Month March, Year- 2025, Impact-Factor, RPRI-3.87.

Dr. Neeraj Yadav
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