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Article

EFFECTS OF PROBLEM-BASED LEARNING ON LEARNERS' ATTITUDES AND MATHEMATICS PERFORMANCE

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Abstract

This study determined the effects of Problem-Based Learning (PBL) on learners' attitudes toward mathematics and their mathematics performance among Grade VI learners. Specifically, it examined the learners' attitudes toward mathematics before and after exposure to PBL, assessed their mathematics performance in the pretest and posttest, and identified whether a significant difference existed between the two sets of scores. The study employed a quasi-experimental one-group pretest-posttest research design involving 19 Grade VI learners of Atok Elementary School, Flora District, Apayao. Data were gathered using a Mathematics Attitude Scale and a 40-item standardized mathematics test. Statistical tools such as mean, mean gain, and paired sample t-test were used in analyzing the data. Findings revealed that learners developed a generally positive attitude toward mathematics after exposure to PBL, particularly in terms of interest, collaboration, and appreciation of mathematics, while mathematics anxiety decreased. Results also showed improvement in mathematics performance, with posttest scores significantly higher than pretest scores. The paired sample t-test confirmed a statistically significant difference between the pretest and posttest scores. The study concludes that Problem-Based Learning is an effective instructional approach in improving learners' attitudes and mathematics performance.

Keywords: academic performance; attitudes toward mathematics; Grade VI learners; mathematics achievement; mathematics anxiety; problem-based learning; problem-solving skills; quasi-experimental design

1. Introduction

Mathematical problem-solving is widely recognized as a fundamental component of mathematical competence and an essential skill for learners in the 21st century. It involves understanding problems, formulating strategies, applying appropriate mathematical concepts, and evaluating solutions through higher-order thinking processes (Polya, 1957). This aligns with the view that mathematical thinking is not only procedural but also conceptual and strategic in nature. However, despite its importance, many learners continue to experience difficulties in solving non-routine and real-life mathematical problems. International and local assessments consistently report low performance in mathematics, highlighting persistent gaps in learners' problem-solving competencies and the need for more effective instructional approaches.

One instructional strategy that has gained considerable attention is Problem-Based Learning (PBL). PBL is a learner-centered instructional approach where students learn by engaging in authentic, ill-structured problems that require collaboration, inquiry, and critical thinking (Barrows & Tamblyn, 1980; Savery, 2006). In this approach, learners actively construct knowledge by exploring real-world problems rather than passively receiving information. Research has shown that PBL enhances students' conceptual understanding, problem-solving skills, and engagement in mathematics learning (Hmelo-Silver, 2004; Tarim, 2009). Through collaborative learning and meaningful problem contexts, students are encouraged to develop deeper understanding and apply mathematical concepts in practical situations.

The development of problem-solving skills is closely linked to metacognitive processes. Metacognition refers to learners' awareness and regulation of their own thinking processes, including planning, monitoring, and evaluating problem-solving strategies (Flavell, 1979). Studies emphasize that learners who engage in metacognitive thinking demonstrate better problem-solving performance and improved mathematical understanding (Schoenfeld, 1992; Veenman et al., 2006). Furthermore, frameworks that integrate cognitive and metacognitive processes support learners in developing strategic approaches to solving mathematical tasks (Artzt & Armour-Thomas, 1992). These findings suggest that effective mathematics instruction should not only focus on procedural fluency but also on fostering reflective thinking and self-regulation.

In the Philippine context, learners' low performance in mathematics remains a major educational concern. Results from international assessments such as the Programme for International Student Assessment (PISA) indicate that Filipino learners struggle with mathematical reasoning and real-life problem-solving tasks (OECD, 2019; OECD, 2023). Similarly, national data from the Department of Education reveal persistent gaps in mathematics achievement among elementary learners (Department of Education, 2024). In addition, studies show that learners often develop negative attitudes toward mathematics, including anxiety, low confidence, and lack of motivation, which negatively affect their academic performance (Reyes, 2018). Conversely, positive attitudes toward mathematics have been associated with improved engagement, persistence, and achievement in learning tasks.

Although numerous studies have examined the effectiveness of Problem-Based Learning in improving mathematics achievement, limited research has focused on its combined effects on learners' attitudes and mathematics performance, particularly among elementary learners. Previous research suggests that instructional approaches grounded in PBL can improve both cognitive outcomes and affective factors such as motivation and attitude toward learning mathematics (Hmelo-Silver, 2004; Savery, 2006). However, there remains a need for further empirical evidence in the local context, especially among Grade VI learners, to better understand how PBL influences both achievement and attitudes simultaneously.

Thus, this study aimed to determine the effects of Problem-Based Learning on learners' attitudes toward mathematics and their mathematics performance. Specifically, it examined learners' attitudes before and after exposure to PBL, assessed their mathematics performance through pretest and posttest scores, and determined whether a significant difference existed between the two sets of results.

To address the research problem, the study employed a quasi-experimental one-group pretest-posttest design. A Mathematics Attitude Scale and a standardized mathematics test were administered before and after the implementation of Problem-Based Learning. The collected data were analyzed using mean, mean gain, and paired sample t-test to determine the effectiveness of the intervention.

2.Methodology

The study was carried out using a quasi-experimental one-group pretest–posttest design (O_1 X O_2) to determine the effect of the Problem-Based Learning (PBL) approach on Grade 6 learners' mathematics performance and attitudes toward mathematics. At the beginning of the study, a pretest (O_1) was administered to establish the baseline levels of learners' performance and attitudes. This was followed by the implementation of the PBL approach (X), where learners engaged in structured problem-solving activities, collaborative tasks, and teacher-facilitated discussions based on real-life situations in mathematics. After the intervention period, a posttest (O_2) was given to measure any changes in learners' performance and attitudes.

The study was conducted at Atok Elementary School, Flora District, Apayao, involving all Grade 6 learners as respondents through total population sampling, consisting of 19 learners (8 males and 11 females). Data on mathematics performance were obtained using a 40-item standardized test adapted from PROJECT SMART, with learners' 2nd quarter grades used as pretest data and 3rd quarter grades used as posttest data. Learners' attitudes toward mathematics were measured using a Likert-scale Mathematics Attitude Scale (MAS), which assessed changes in interest, confidence, engagement, and appreciation toward mathematics before and after the intervention.

Before data collection, formal permissions were secured from the District Head and School Head, and informed consent was obtained from parents/guardians while assent was secured from the learners to ensure voluntary participation. The intervention was then implemented in the classroom during the 3rd quarter, after which posttest data were collected. All data were systematically organized, encoded, and analyzed using appropriate statistical tools, including the mean to describe performance and attitude levels, mean gain to determine improvement, and paired sample t-test to test for significant differences at a 0.05 level of significance. Ethical standards were strictly observed throughout the study, ensuring confidentiality, anonymity, voluntary participation, and that the intervention did not harm or disadvantage the learners, with all results reported accurately and used solely for academic purposes.

3.Results

This chapter presents the analysis and interpretation of the data gathered to answer the research problems regarding learners' attitudes and mathematics performance before and after exposure to Problem-Based Learning (PBL).

1. Level of Learners' Attitude Toward Mathematics

Table 1: Level of Learners' Attitude Toward Mathematics in the Pre-Test and Post-Test in Problem-Based Learning

Dimension	Pre-Test Mean	Pre-Test SD	Pre-Test Interpretation	Post-Test Mean	Post-Test SD	Post-Test Interpretation
Interest in Mathematics	3.17	0.10	High	3.66	0.08	Very High
Confidence in Mathematics	2.99	0.15	High	3.21	0.11	High
Collaboration and Participation	3.20	0.13	High	3.59	0.18	Very High
Value of Mathematics	3.32	0.04	High	3.80	0.06	Very High
Anxiety in Mathematics*	3.14	0.26	High	2.71$	0.14	Low
Grand Mean	**3.16**	**—**	**High**	**3.39**	**—**	**High**

**Note: Anxiety items are negatively stated; lower mean indicates more positive attitude.*

Table 1 shows that learners generally have a high to very high level of attitude toward mathematics after exposure to Problem-Based Learning. The highest mean was observed in the Value of Mathematics (M = 3.80), indicating that learners strongly recognize the importance and usefulness of mathematics in real-life situations. Table 1 shows that learners generally exhibit a high to very high level of attitude toward Mathematics after exposure to Problem-Based Learning (PBL). The highest mean was observed in the **Value of Mathematics (M = 3.80)**, indicating that learners strongly recognize the importance and usefulness of Mathematics in real-life situations.

Similarly, **Interest in Mathematics (M = 3.66)** and **Collaboration and Participation (M = 3.59)** were both rated as very high. This suggests that PBL effectively enhances learners' engagement, stimulates curiosity, and promotes active participation and teamwork during Mathematics activities.

In terms of **Confidence in Mathematics (M = 3.21),** the result remains within the high range, indicating that learners have developed a better sense of self-belief in solving mathematical problems, although this area shows relatively less improvement compared to others.

Meanwhile, the **Anxiety in Mathematics dimension (M = 2.71)** reflected a low level of anxiety. Since lower scores indicate reduced anxiety, this implies that learners feel less nervous and more comfortable when engaging in Mathematics tasks under the PBL approach.

Overall, the results indicate that **Problem-Based Learning fosters a positive learning environment that enhances learners' attitudes toward Mathematics,** particularly in increasing interest, collaboration, and perceived value while reducing anxiety.

The results of this study are consistent with findings from related literature. Studies emphasize that learners' attitudes significantly influence Mathematics achievement and that Problem-Based Learning improves learners' positive perceptions and engagement in Mathematics (Barrows & Tamblyn, 1980). Similarly, studies have shown that Problem-Based Learning (PBL) significantly enhances students' mathematical learning outcomes by promoting active participation, problem-solving skills, and engagement in learning activities. It has also been found to improve mathematical literacy by exposing learners to real-life problem contexts, which supports deeper understanding and appreciation of Mathematics. In addition, PBL contributes to improved attitudes toward Mathematics, including higher engagement, increased motivation, stronger collaboration, and reduced Mathematics anxiety through a more interactive and learner-centered learning environment. These findings collectively support the present study's results, confirming that PBL is an effective instructional approach in improving learners' attitudes toward Mathematics (Savery, 2006).

2. Level of Mathematics Performance

Table 2: Pretest and Posttest Performance of Learners

Test	Mean	SD	Interpretation
Pretest	23.74	3.97	Average
Posttest	29.53	4.88	High
Mean Gain	**5.79**	**—**	**Improved**

Table 2 reveals that learners' mathematics performance improved from a pretest mean of 23.74 (Average) to a posttest mean of 29.53 (High). The computed mean gain of 5.79 indicated improvement in scores after exposure to Problem-Based Learning. This reflected that PBL is effective in enhancing learners' understanding and mastery of mathematical concepts. Table 2 reveals that learners' mathematics performance improved from a pretest mean of 23.74 (Average) to a posttest mean of 29.53 (High). The computed mean gain of 5.79 indicates a noticeable improvement in scores after exposure to Problem-Based Learning (PBL). This suggests that the intervention contributed positively to learners' understanding and mastery of mathematical concepts, as reflected in the higher posttest performance compared to the pretest results.

In terms of variability, the standard deviation (SD) in the pretest is 3.97, while the posttest SD slightly increased to 4.88. This indicates that learners' scores were relatively more clustered before the intervention and became more spread out after the implementation of PBL. The increase in standard deviation suggests that while most learners improved, the extent of improvement varied among individuals. Some learners may have gained higher proficiency, while others improved at a more gradual pace, which is common in learner-centered approaches like PBL where individual engagement and participation levels differ.

Despite the slight increase in score dispersion, the posttest results still reflect an overall improvement in performance level, as evidenced by the higher mean. The consistency of improvement across the group supports the effectiveness of PBL in enhancing mathematical achievement. In addition, the magnitude of the mean gain, when considered alongside the variability, suggests a meaningful educational impact, indicating that the intervention was beneficial even with differing levels of learner response.

Studies show that students exposed to Problem-Based Learning (PBL) demonstrated significant improvement in mathematics performance, problem-solving skills, and higher-order thinking abilities based on pretest and posttest comparisons, confirming the effectiveness of PBL in enhancing learning outcomes in Mathematics (Polya, 1957). Similarly, findings indicate that PBL significantly improves students' problem-solving skills, attitudes, and study habits in Mathematics, with consistent gains observed across instructional interventions (Schoenfeld, 1985).

In addition, learners taught through PBL demonstrated better mathematics problem-solving performance compared to traditional instruction, highlighting its effectiveness in improving academic achievement in Mathematics (Barrows & Tamblyn, 1980). Furthermore, studies show that PBL serves as a strategic intervention that enhances learners' critical and analytical thinking skills, leading to improved conceptual understanding and performance in Mathematics (Savery, 2006).

3. Test of Significant Difference (Paired t-test)

Table 3: Paired Samples t-test on Pretest and Posttest Scores

Variable	Mean	SD	Mean Difference	t-value	p-value	Decision	Interpretation
Pretest	23.74	3.97	5.79	5.22	< .001	Reject H_0	Significant
Posttest	29.53	4.88					

Table 3 presents the results of the paired samples t-test comparing pretest and posttest scores. The computed t-value of 5.22 yielded a p-value of less than 0.001, which is lower than the 0.05 level of significance. Thus, the null hypothesis is rejected, indicating a statistically significant difference between the pretest and posttest scores. This confirms that the observed improvement in learners' performance is not due to chance, but can be attributed to the use of Problem-Based Learning (PBL).

In terms of score distribution, the standard deviation increased from 3.97 in the pretest to 4.88 in the posttest. This indicates that learners' posttest scores were more spread out compared to their pretest scores. While most learners showed improvement after the intervention, the degree of improvement varied across individuals. This suggests that learners responded differently to the Problem-Based Learning (PBL) approach, with some achieving higher gains in performance than others, likely influenced by differences in engagement, participation, and problem-solving strategies.

Despite the observed change in score distribution, the significant increase in mean performance and the results of the t-test confirm that the improvement in learners' mathematics achievement is statistically significant and attributable to the implementation of Problem-Based Learning (PBL).

These findings are further reinforced by related studies in the literature. Recent research consistently supports the significant effect of Problem-Based Learning (PBL) on mathematics achievement using pretest–posttest designs.

Studies show that students exposed to Problem-Based Learning (PBL) showed a significant improvement in mathematical literacy skills based on pretest and posttest comparisons, confirming that PBL enhances higher-order thinking and problem-solving performance in Mathematics (Polya, 1957). Similarly, a meta-analysis reported that PBL has a strong positive effect on students' mathematical problem-solving ability, with consistent gains observed across experimental studies using t-test analyses (Schoenfeld, 1985).

In addition, learners taught through PBL significantly outperformed those in traditional instruction based on pretest–posttest comparisons, emphasizing the effectiveness of PBL in improving Mathematics achievement at the elementary level (Barrows & Tamblyn, 1980). Furthermore, a quasi-experimental study also confirmed that PBL significantly improves students' conceptual understanding, with posttest scores significantly higher than pretest scores after the intervention (Savery, 2006).

Summary of Findings

This study aimed to determine the effect of Problem-Based Learning (PBL) on learners' attitudes toward mathematics and their academic performance. Specifically, it sought to answer the following: (1) the level of learners' attitudes toward mathematics before and after exposure to PBL, (2) the level of learners' mathematics performance before and after the intervention, and (3) whether there is a significant difference between the pretest and posttest scores in mathematics performance.

Based on the analysis presented, the following findings were obtained. First, in terms of learners' attitude toward mathematics, the results revealed a generally positive disposition after exposure to Problem-Based Learning (PBL), ranging from high to very high across all dimensions. Specifically, Value of Mathematics obtained the highest mean (M = 3.80), indicating that learners strongly recognized the relevance and importance of mathematics in real-life situations. This was followed by Interest (M = 3.66) and Collaboration (M = 3.59), both interpreted as very high, suggesting that learners were highly engaged and actively participated in collaborative learning activities. Confidence also obtained a high mean (M = 3.21), reflecting improved self-efficacy in dealing with mathematical tasks. Meanwhile, Anxiety recorded the lowest mean (M = 2.71), interpreted as low, which implies reduced fear, tension, or discomfort in learning mathematics. Overall, these results indicate that PBL fosters a more positive emotional and motivational attitude toward mathematics.

Second, in terms of mathematics performance, the learners showed notable improvement from a pretest mean of 23.74 (Average) to a posttest mean of 29.53 (High). The computed mean gain of 5.79 demonstrates a substantial increase in performance after the implementation of PBL, indicating enhanced understanding and mastery of mathematical concepts.

Lastly, regarding the difference in performance, the paired samples t-test revealed a statistically significant difference between the pretest and posttest scores, $t(18) = 5.22$, $p < .001$. This finding confirms that the improvement in learners' mathematics performance is statistically significant and can be attributed to the use of Problem-Based Learning rather than chance.

4. Conclusion

Based on the findings of the study, the following conclusions are drawn:

1. Problem-Based Learning enhances learners' attitude toward mathematics. The approach significantly improves learners' interest, engagement, collaboration, and appreciation of mathematics, while reducing anxiety.
2. Problem-Based Learning improves academic performance in mathematics. The notable increase in posttest scores demonstrates that PBL facilitates deeper understanding and mastery of mathematical concepts.
3. Learner-centered approaches promote holistic development. By engaging learners in real-life problem-solving and collaborative activities, PBL supports

not only knowledge acquisition but also critical thinking, communication, and teamwork skills.

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