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Problem-Based Learning in Advancing the Problem-Solving Skills in Mathematics

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Abstract*: Mathematics subjects aim to improve students' problem-solving skills, but often produce poor outcomes. This study determined how problem-based learning (PBL) improves students' problem-solving skills in mathematics in the fifth-grade. This study utilized the quantitative type of method, using a pre-experimental design. The respondents were 40 elementary students in a select school in the Second District of Western Pampanga. This study made use of the experimental group. Purposive sampling is utilized to select a subset of individuals or units for testing. The researchers crafted self-made questionnaires. The problem-solving skills test consisted of 6 items in the form of word problems. The researchers administered a pre-test to the respondents to determine their current level of skill in mathematics. The instructor of the class conducted an intervention following the administration of the pre-test. After that, a post-test with the same questions as the pre-test were given out. The findings demonstrated that the application of the Problem-Based Learning (PBL) model significantly improved the ability of fifth-grade students to solve mathematical problems in a chosen school in the Second District of Western Pampanga.*

Keywords: *problem-based learning; problem-solving skills; mathematics*

INTRODUCTION

Background of the Study

In today's generation, learners in the twenty-first century must be prepared with the fundamental information and abilities needed to function in a variety of settings. As a result, modern education is undergoing a genuine shift that has helped to emphasize this century's imperatives for humanity to adapt to shifting demands and anticipations. It also established a foundation for estimating the abilities that children will need to learn, including critical contemplating.

Problem-solving in mathematics plays a vital role in managing the classroom. Considering the challenges that develop in the daily lives of people as a form of problems, and problem-solving abilities enable individuals to conquer these types of challenges. As a result, problem-solving skills play a crucial role in mathematics and our real lives and should be transformed into one of the twenty-first-century teaching approaches (Ozrecberoglu & Çağanağa, 2017). Moreover, students' problem-solving abilities in higher education are influenced by their elementary school learning experiences (Suhartono, 2018).

Mathematics subjects aim to improve students' problem-solving however often produce poor outcomes. According to the study of Fauzi et al., (2023), several findings indicate that students struggle with mathematical problem-solving skills, including their inability to understand various relationships and concepts presented in the problem, to understand mathematical concepts, their inability to perform mathematical reasoning, and their inability to solve story problems. The majority of students, according to the most recent national test results, are incapable of solving mathematical problems. This contributes to the general perception that mathematics achievement is relatively low. Additionally, it signifies that students encounter challenges in understanding mathematical problems, which hinders their ability to solve them. Therefore, instructors may be able to develop an appropriate lesson plan that corresponds to the learning process of their students (Phonapichat et al., 2014).

Furthermore, to deal with these challenges, the teacher can help students learn by giving strategies that allow students to think critically and solve problemsAlthough many teaching models have been proposed, problem-based learning, or PBL, is thought to be the most beneficial approach (Adhianto et al., 2020). According to a 2017 study by Amalia et al., students' ability to solve mathematical problems can be greatly improved by Problem-Based Learning (PBL). As a result, PBL integration into instruction is a very successful way to help students develop these skills.

According to Anazifa (2016), using problem-based learning improves student knowledge and encourages student participation during the teaching and learning process. PBL helps students understand the contextual challenge more fully by utilizing their factual knowledge. Real-world scenarios are used as the backdrop for students' learning in the framework of problem-based learning. Usually, it begins with exposing pupils to real-world or hypothetical scenarios (Arviana et al., 2018). Moreover, in the study of Rindengan and Wenas (2020), Problem-Based Learning (PBL) was described as an educational approach in which students face real-world and engaging situations, pushing them to build their own knowledge base, improve their problem-solving abilities,

and figure out solutions to the problems presented. In the PBL framework, students engage a role in the learning process, focusing on addressing challenges connected to the subject matter being studied, establishing a student-centered learning environment.

The idea that PBL of Barrow should include as one of its fundamental features is that students study in small groups. PBL places students in small groups so they can come up with ideas and do independent research. Every learner has a unique position in the group, and these roles change frequently. The small group activities center on the learners' self-reflections to assist them in creating their own understanding (Boye & Agyei, 2013). As a result, the learner is at the center of the process; instruction occurs in small groups; teachers facilitate learning or act as guides; learners begin with authentic problems; these problems are used to help learners understand the concepts of mathematics; and self-directed learning is employed to gather up new information. Furthermore, according to the study of Ali (2019), PBL teaches students how to collaborate in groups, become partners in the teaching and learning process, handle a variety of scenarios, and build skills for lifelong learning.

In the study conducted by Adhianto (2020) and Rindengan & Wenas (2019), both studies utilized a qualitative method of study and quasi-experimental research design in examining the effectiveness of problem-based learning among primary and high school students. Based on the analysis and discussions of the research results, the findings indicate that the students showed better achievement with problem-based learning (PBL), therefore PBL is effective for enhancing the mathematical problem-solving skills in primary and junior high school students.

This study determined how problem-based learning (PBL) improves students' problem-solving skills in mathematics of the fifth-grade students.

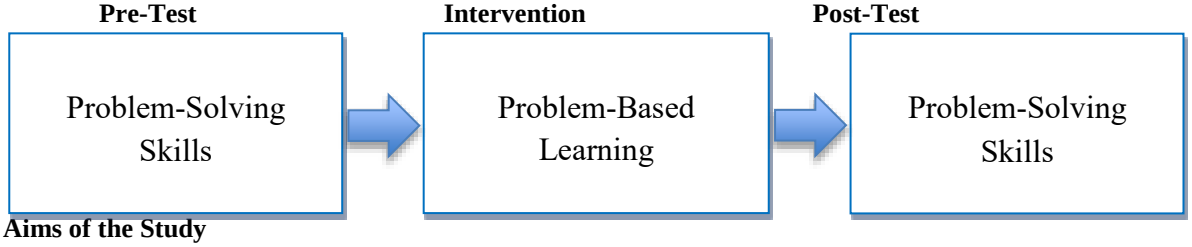
Theoretical Framework

This study is supported by the theory of Constructivist Learning Theory. This theory was developed by Swiss Psychologist Jean William Fritz Piaget in 1976. According to Kurt (2021), the basic principle of constructivist learning theory is that knowledge is created via experiences, and that students actively participate in their education. Every person evaluates what they have experienced and integrates new ideas into what they already know as events take place. Understanding how students learn mainly relies on constructivist learning theory. The idea that students actively generate knowledge is the core of constructivism. Students layer their fresh experiences on top of their current knowledge. Learning is an active cognitive process, not a passive recipient of instruction.

In accordance with the constructivist learning theory, meaningful learning happens when individuals build knowledge based on existing schemas and perspectives from others. Problem-based learning is a useful strategy in a constructive classroom to promote meaningful learning. Students in the constructivist classroom are active participants, not passive listeners. Students engage in problem-solving tasks and high-level cognitive processes, which promote creativity and motivation. It allows pupils to gain both mental and physical experience. Problem-based learning involves authentic challenges, scaffolded instruction, and social engagement to help students solve them independently (John & Thomas, 2014).

Conceptual Framework

This study used a pre-experimental research design and was designated as follows: pre-test, intervention using problem-based learning, post-test. As shown by the figure below, students underwent pre-test examination before the implementation of the PBL model. After the administration of the pre-test, the PBL model intervention was given. Lastly, a post-test was administered containing the same content as the pre-test to test the problem-solving skills of the students.



Aims of the Study

This study aimed to determine the problem-solving skills of elementary students through problem-based learning in Mathematics. Particularly, the following questions were answered:

1. How may the students in the group be described before the implementation of Problem-Based Learning in terms of their problem-solving skills?
2. How may the student in the group be described after the implementation of Problem-Based Learning in terms of their problem-solving skills?

3. Is there a significant difference in the performance of the participants before and after the implementation of Problem-Based Learning?

Hypothesis

There is a significant difference in the performance of the fifth-grade students' problem-solving skills before and after the implementation of problem-based learning.

.METHOD

Research Design

This study utilized the Quantitative type of method. According to Creswell (2014), in order to figure out how PBL affects students' problem-solving skills, a pre-test and post-test treatment are all included for a single group utilizing a pre-experimental design. The PBL model is the independent variable, while problem-solving skills are the dependent variable. According to Behlol et al. (2018), this design was deemed useful since it could regulate the threats to the experiment's internal and external validity including testing, instrumentation, history, maturity, statistical regression, and experimental effects. The aim of quantitative research is to gather numerical data, generalize it to other populations, or provide an explanation for a particular phenomenon. The purpose of this strategy was to determine how well elementary pupils' problem-solving abilities could be improved.

Respondents of the Study

A total of 40 elementary school students from a select school in the Second District of Western Pampanga, specifically in the municipality of Porac, served as respondents in the study.

In conducting this research, purposive sampling technique was used. According to Heath (2023), purposive sampling is utilized to select a subset of individuals or units for testing. When the researcher has a unique concept of the features or characteristics they desire to explore and wishes to select a sample that is representative of those features or characteristics, this method is suitable.

The researchers produced the sample through purposive sampling in which they easily chose their participants. In choosing the sampling technique, the researchers came up with a technique that will best help in the study.

Instrument

The researchers crafted self-made test questionnaires. The test was drawn out through the reading of the researchers from different DepEd modules, books, and worksheets relevant to the study. The problem-solving skills test consisted of 10 items about the topic Volume of a Cube and A Rectangular Prism in the form of word problems. The basic clarification, decision-making, adjustments to the basic competencies, and conclusion indicators of problem-solving skills tests were taken into consideration when developing the instrument. To make sure that the tests were correct and valid, the researchers presented the first draft to the adviser for some checking and further suggestions. The test questionnaires were submitted for scrutiny of five experts for content validation; two elementary master teachers, a Grade V mathematics teacher, a mathematics instructor from the College of Education, and an expert in English Language and Literature Teaching. The validation involves assessing (1) the suitability of the questions, (2) the difficulty level of the questions, (3) the clarity and appropriateness of the language used, and (4) the accuracy of the concepts. After the validation, the instrument underwent pilot testing to 20 fifth-grade students in a selected school in the Second District of Western Pampanga. In the results of the pilot testing, 6 questions passed the reliability test having Cronbach's alpha coefficients 0.74, signifying a good level of reliability. This implies that the self-made questionnaire by the researchers is deemed reliable. The scoring rubric for students' problem-solving skills was adapted from the study of Buan (2018) titled "Students' Creative Thinking and Problem-Solving Skills in Mathematics".

Data Collection

In the administration of the test questionnaires, the researchers requested permission through a letter from the dean of the College of Education. Upon approval, the letter was sent to the principal of the chosen school in Second District Western, Pampanga. The researchers asked permission to administer pre-test and post-test to the class adviser and students of Grade V. The researchers gave the respondents a pre-test after the request was granted. The class teacher conducted an intervention following the administration of the pre-test. After that, a post-test with the identical questions as the pre-test was given out. Ultimately, these were verified, totaled, graded, deciphered, and examined once the test was retrieved. Using descriptive analysis, the pre- and post-test outcomes were examined.

Data Analysis

The mean, standard deviation, and paired t-test analysis were used to examine the data in this study. These ascertained how students' problem-solving abilities were affected by problem-based learning. The data that described the respondents' problem-

solving abilities both before and after the implementation was analyzed using the mean and standard deviation. Moreover, the averages/means and standard deviations of the two linked groups were compared using the paired t-test to determine if there was a significant difference. The paired t-test also examined variations within a single group. It appears that there is a relationship between the score groupings because the respondents for both measurement pairs are on the same themes. Use a paired t-test if the groups are from the same population. For example, when comparing measurements taken before and after an experimental treatment (Bevans, 2023).

Ethical Considerations

The researchers made sure that they adhered to the Data Privacy Act of 2012 while carrying out the study. The researchers also applied the principles of ethical considerations developed by Bryman and Bell (2007), in which the participants in this study would not experience any negative effects from taking part in it. Complete consent will be sought from the participants, pupils, and instructors of the chosen school in the Second District of Western Pampanga prior to the study's implementation. Furthermore, measures will be taken to safeguard research participants' privacy. The research subjects' voluntary participation will be given great importance. Furthermore, correspondence soliciting consent will be addressed to the principals of the educational institutions where the research was executed. The researchers ensure that all respondents' rights to privacy and the confidentiality of the data they have provided will be upheld with the utmost regard. Participants are granted the right to be informed of the anticipated repercussions of refusing to partake in the study, in addition to the ability to discontinue their involvement once it has commenced.

Furthermore, the researcher assured the respondents that all data coming from them would be used for the sole purpose of this study.

Statistical Treatment

In interpreting the gathered and analyzed data, scale for descriptive analysis was used. The descriptive analysis scale classifies the scores into four categories of proficiency: novice, apprentice, practitioner, and expert. This category aids in assessing respondents' competence levels based on their mean scores, offering a clear idea of their abilities in the context of problem-solving.

Interpretation of Results

1. **Novice (0 - 11)**
   Respondents scoring between 0 to 11 are categorized as Novices. This score range signifies a fundamental or beginner level of proficiency. Typically, novices show limited comprehension of the problems, use incorrect strategies, fail to show their computations, and do not meet the problems' requirements.

2. **Apprentice (12 - 23)**
   Respondents scoring between 12 to 23 are placed in the Apprentice category. Apprentices have surpassed the basic level and are progressing in their skill development. Typically, they may misinterpret parts of the problems, struggle to apply strategies correctly, perform incomplete computations, and meet most requirements, however provide incorrect answers.

3. **Practitioner (24 - 35)**
   Practitioner level is assigned to respondents scoring between 24 to 35. This group exhibits a competent level of proficiency, displaying a foundational grasp of the problem at hand. Practitioners apply strategies accurately, provide thorough computations, and generally fulfill the requirements of the problem. However, there may be instances where their answers are partially incorrect.

4. **Expert (36 - 48)**
   Respondents scoring 26 to 48 are classified as Experts. This group demonstrates a high level of proficiency, possessing advanced knowledge and skills. Experts display a comprehensive understanding of the problem, apply efficient strategies with precise data, and provide thorough and accurate computations. They consistently meet all the requirements of the problem, delivering correct answers.

RESULTS AND DISCUSSIONS

Graph 1.1 Percentage of Students' Level of Problem-Solving Skills on Volume of a Rectangular Prism Before the Implementation of PBL

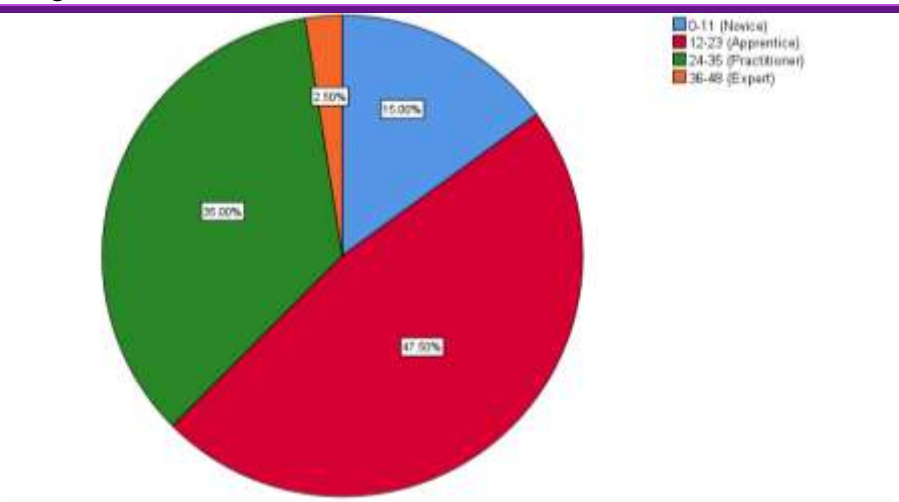


Table 1.1 Frequency Table of Percentage of Students' Level of Problem-Solving Skills on Volume of a Rectangular Prism Before the Implementation of PBL

		Frequency	Percent	Interpretation
Range of Scores	0-11	6	15	*NOVICE*
	12-23	19	47.50	*APPRENTICE*
	24-35	14	35	*PRACTITIONER*
	36-48	1	2.50	*EXPERT*
	Total	**40**	**100**	

Graph 1.1 shows the percentage of students who got scores within the corresponding range in the pretest for questions concerning volume of rectangular prisms (pretest) and Table 1.1 shows the frequency of students who got those scores and the corresponding interpretation. Based on the results, 15% of the students are in the NOVICE status, 47.50% got APPRENTICE rating, 35% got PRACTITIONER, and only 2.50% got an EXPERT rating.

Graph 1.2 Percentage of Students' Level of Problem-Solving Skills on Volume of a Cube Before the Implementation of PBL

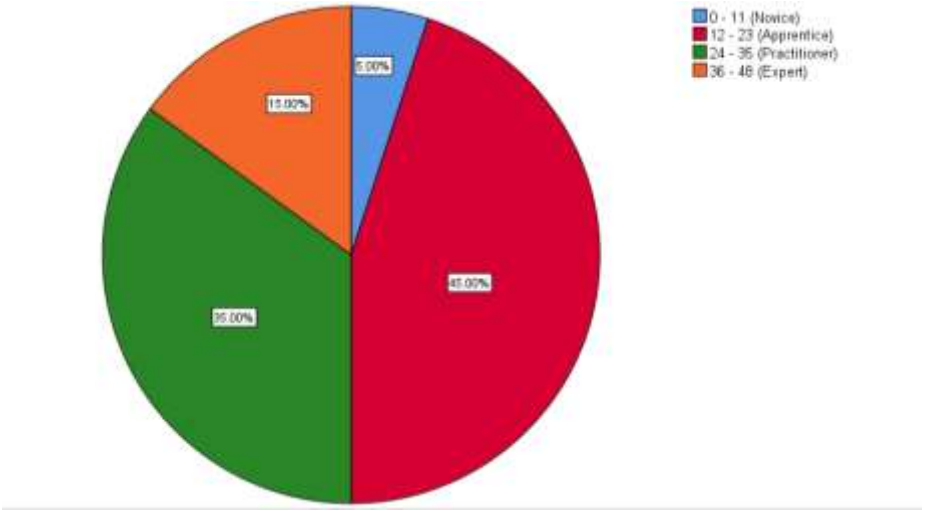


Table 1.2 Frequency Table of Percentage of Students' Level of Problem-Solving Skills on Volume of a Cube Before the Implementation of PBL

	Frequency	Percent	Interpretation

Range of Scores	0-11	2	5.0	*NOVICE*
	12-23	18	45	*APPRENTICE*
	24-35	14	35	*PRACTITIONER*
	36-48	6	15	*EXPERT*
	Total	**40**	**100**	

Graph 1.2 shows the percentage of students who got scores within the corresponding range in the pretest for questions concerning volume of a cube (pre-test) and Table 1.2 shows the frequency of students who got those scores and the corresponding interpretation. Based on the results, 5% of the students are rated NOVICE, 45% as APPRENTICE, 35% as PRACTITIONER and 15% as EXPERT.

According to Nurfauzi (2020), pupils' pre-test results were lower and thus, when compared to the post-test scores, learning through PBL is an effective way to stimulate mathematics learning in elementary classrooms. This could be the result of implementing the problem-based learning approach, whereas student-centered learning was supposed to improve students' active involvement and participation in learning.

Graph 2.1 Percentage of Students' Level of Problem-Solving Skills on Volume of a Rectangular Prism After the Implementation of PBL

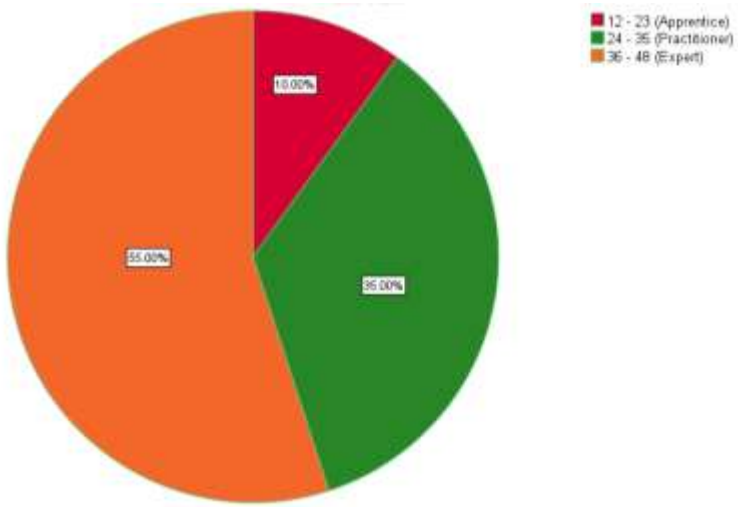


Table 2.1 Frequency Table of Percentage of Students' Level of Problem-Solving Skills on Volume of a Rectangular Prism After the Implementation of PBL

		Frequency	Percent	Interpretation
Range of Scores	0-11	0	0	*NOVICE*
	12-23	4	10	*APPRENTICE*
	24-35	14	35	*PRACTITIONER*
	36-48	22	55	*EXPERT*
	Total	**40**	**100**	

Graph 2.1 shows the percentage of students who got scores within the corresponding range in the pretest for questions concerning volume of rectangular prisms (post-intervention) and Table 2.1 shows the frequency of students who got those scores and the corresponding interpretation. Based on the results, 0% of the students are rated NOVICE, 10% are rated APPRENTICE, 35% are PRACTITIONER, and 55% are rated as EXPERT.

Graph 2.2 Percentage of Students' Level of Problem-Solving Skills on Volume of a Cube After the Implementation of PBL

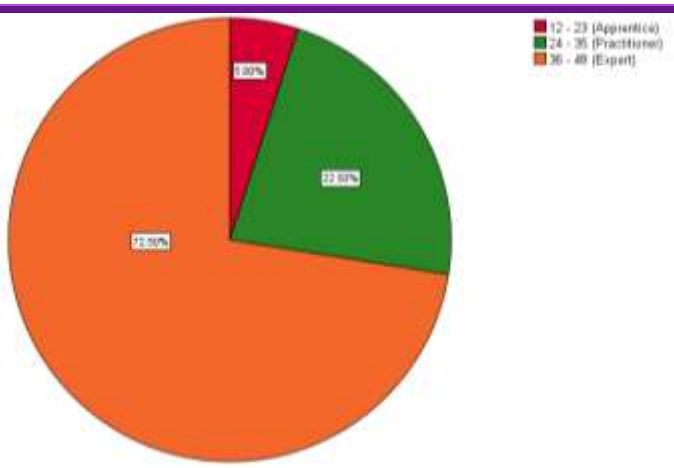


Table 2.2 Frequency Table of Percentage of Students' Level of Problem-Solving Skills on Volume of a Cube After the Implementation of PBL

		Frequency	Percent	Interpretation
Range of Scores	0-11	0	0	*NOVICE*
	12-23	2	5	*APPRENTICE*
	24-35	9	22.5	*PRACTITIONER*
	36-48	29	72.5	*EXPERT*
	Total	**40**	**100**	

Graph 2.2 shows the percentage of students who got scores within the corresponding range in the pretest for questions concerning volume of cubes (post-intervention) and Table 2.1 shows the frequency of students who got those scores and the corresponding interpretation. Based on the results, 0% of the students are rated NOVICE, 5% are rated APPRENTICE, 22.50% are PRACTITIONER, and 72.50% are rated as EXPERT.

Students who learned using PBL performed higher on post-tests in the test results. Learning through PBL is an effective way to stimulate mathematics learning in elementary classrooms. According to Crowley (2015), students who studied using a problem-based learning model have higher competence than students who learn using a standard learning model. It can be concluded that students who learn using a problem-based learning model have higher improvements in their critical thinking skills than students who learn using a standard learning model. This is due to the fact that Problem-Based Learning is an approach that starts with posing actual or real-world challenges to students, forcing them to exercise critical thought and acting as problem solvers in order to develop their skills.

Table 3.1 Significant Difference of Students' Problem-Solving Skills on Volume of a Rectangular Prisms Before and After the Implementation of Problem-Based Learning

Test	Mean of Total Score	Std. Dev.	df	t-value	Sig.	Interpretation
PRETEST	20.75	8.32	39	-10.42	0.001	**Significant**
POSTTEST	36.25	8.10				

The mean of the total scores for rectangular prism questions in the pretest is 20.75 and 36.25 for the posttest. By t-test difference of means analysis resulted in a 0.001 significance which means that there is a significant difference between the scores before and after the implementation of the problem-based learning.

Table 3.2 Significant Difference of Students' Problem-Solving Skills on Volume of a Cube Before and After the Implementation of Problem-Based Learning

Test	Mean of Total Score	Std. Dev.	df	t-value	Sig.	Interpretation
PRETEST	24.08	9.55	39	-9.84	0.001	**Significant**
POSTTEST	38.25	7.37				

The mean of the total scores for volume of cube questions in the pretest is 24.08 and 38.25 for the posttest. By t-test difference of means analysis resulted in a 0.001 significance which means that there is a significant difference between the scores before and after the implementation of the problem-based learning.

The experimental group showed a statistically significant improvement, implying that the PBL intervention resulted in higher transferable skills following the PBL intervention. The high post-test scores found in this study could be attributed to PBL's effectiveness in helping students understand mathematical concepts by connecting them to everyday circumstances. Furthermore, pupils' problem-solving abilities improved significantly when teachers linked the learning content to real-life scenarios (Haryanto, 2020).

-CONCLUSIONS, LIMITATIONS, AND RECOMMENDATIONS

Conclusions

The purpose of this study was to determine the problem-solving skills of elementary students through problem-based learning in Mathematics. Based on the results of the study, the researchers drew the following conclusions:

1. The majority of fifth-grade students at the chosen school in the Second District of Western Pampanga were classified as apprentices in terms of their problem-solving skills, prior to the implementation of the Problem-Based Learning.
2. After the implementation of Problem-Based Learning, the fifth-grade students at the chosen school in the Second District of Western Pampanga were categorized as experts in their problem-solving abilities.
3. The Problem-Based Learning has been a helpful method in enhancing the mathematical problem-solving abilities of fifth-grade students.

Limitations

Several limitations were encountered in this study. First, this study only determined the effect of problem-based learning on the students on a specific Mathematics topic, volume of a cube and a rectangular prism. Second, due to time constraints, the implementation of the intervention was carried out in just a few days. This short duration for the intervention might not be sufficient to observe the long-term effects of PBL on the problem-solving abilities of the students in Mathematics. Third, the respondents were limited to only 40 fifth-grade students, as a result, the findings may not be applicable to other schools or larger sample size. Lastly, the differences in teaching styles and level of competence among teachers who implemented the intervention were not controlled. These changes may have altered the effectiveness of the intervention, making it challenging to determine the effects of Problem-Based Learning.

Recommendations

Based on the findings of the study, recommendations were made to improve the effectiveness of Problem-Based Learning in enhancing the problem-solving skills of the fifth-grade students. The following are the proposed suggestions of the researchers:

1. It is advised that further studies be carried out to assess the effectiveness of the PBL in different and various contexts.
2. To reduce errors and obtain more reliable results of the study, it is hoped that the next researchers will be able to conduct research with a larger population or sample size.
3. In elementary school, implementing Problem-Based Learning as alternative forms of instruction can help learners improve their Problem-Solving Skills. To ensure that the learning is implemented effectively, it is necessary to pay attention to the learning processes when applying this pedagogy. Furthermore, educators must guide and serve as the facilitator of the class during the intervention.
4. For future researchers, it would be ideal if the intervention will be used for a longer duration to determine whether the observed improvement of the students sustained overtime.

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