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Problem-Based Learning on Improving the Problem-Solving Skills, Attitudes, and Study Habits in Mathematics*

Abstract. Mathematics is a fundamental subject in education, and proficiency in mathematical problem-solving is a key competency for success in various academic and professional domains. To foster this competency, educators have employed various teaching methodologies, one of which is problem-based learning (PBL). This study employed a quasi-experimental design to analyze the effects of PBL on improving the problem-solving skills, attitudes, and study habits in mathematics among Grade 6 pupils. Prior to PBL implementation, the pupils had low problem-solving skills in terms of mean percentage score. The pupils in both the control and experimental groups have a positive attitude towards mathematics. The level of problem-solving skills of the experimental group increased as well as the control group. However, as shown in the results, the mean scores of the experimental group were higher than those of the control group. Meanwhile, the pre-survey and post-survey on study habits have the same verbal interpretation, suggesting that PBL improved the study habits in mathematics among Grade 6 pupils. Results revealed that PBL is a valuable approach for enhancing problem-solving skills, attitudes towards mathematics, and study habits. By employing the principles of PBL effectively, educators can optimize its benefits and create a conducive learning environment that nurtures critical thinking and academic success in mathematics.

Introduction

Education plays a crucial role in developing the human resources necessary for a nation's progress (King, 2011). Broadly defined, education encompasses any activity that significantly contributes to the development of a person's cognitive

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abilities, skills, and attitudes (Lim, 2013). These foundational elements are essential for cultivating a workforce that can drive economic and social advancement.

Every curriculum across the globe includes mathematics, one of the most well-established disciplines (Stein & Kim, 2011). Mathematical literacy and skills encompass a broad understanding, appreciation, and awareness of mathematics' potential applications. This concept goes beyond mere mastery of academic topics or complex formulas; it involves a comprehensive grasp of how mathematics can be applied in various real-world contexts (Macdonald, 2014). Mathematical aptitude plays a crucial role in shaping one's career and overall quality of life. Rather than simply memorizing and following a set of procedures, problem-solving allows students to develop a deeper understanding and articulate the strategies they use to find solutions (Mergendoller et al., 2006).

It makes sense that young children, who are not limited by the need for correct answers, tend to be the most excited and engaged in this area of math, where many adults often feel the least confident. Mathematical problem-solving provides students with hands-on experience in applying their mathematical knowledge and skills to solve real-life problems. One key aspect of mathematical problem-solving that connects real-world issues and applications is word problem solving (de Quadros et al., 2011).

In the Philippines, mathematics is taught as a core subject in both primary and higher education, with the expectation that students will understand and appreciate its principles as they apply them in problem-solving, critical thinking, communication, reasoning, making connections, representing ideas, and making decisions in everyday life through the use of appropriate technology (Guinocor et al., 2020). Casa et al. (2017) argue that mathematics is essential and required in almost every field. However, challenges related to math proficiency persist, not only in the Philippines but also in other countries.

The dire situation was confirmed in the 2019 TIMSS report, which tested math and science skills among Grade 4 pupils. Out of 58 countries, Filipino students ranked the lowest, scoring 297 points in math and 249 points in science. The report further highlighted that these scores – 358 in math and 332 in science – are actually lower than the Philippines' performance in 2003 (Mullis et al., 2020).

The Philippines participated in the 2018 Program for International Student Assessment (PISA), which was conducted by the Organization for Economic Cooperation and Development (OECD) and involved 79 participating economies. The study ranked these economies based on how well they supported their students' academic progress in reading, science, and math. In math (353 and 357) and science, the Philippines ranked at the bottom, with both subjects having an average score of 489 points (Ambag, 2018, as cited in Caramay & Cruz, 2023). Likewise, a national news report on the 2022 PISA results highlighted the critical state of the Philippine school system. Among the 81 participating countries under the Organization for Economic Cooperation and Development (OECD), the Philippines was one of the lowest performers in math, reading, and science, ranking 76th in math. The Philippines scored an average of 355, or Level 1b, significantly below the OECD average of 472, or Level 2 (Hernando-Malipot, 2023).

The teaching strategies or methods employed by educators to convey mathematical concepts are among the many factors that influence the teaching and learning of mathematics (Cardino & Cruz, 2020; Lago & Cruz, 2021). A variety of skills, such as critical thinking, problem-solving, creativity, metacognition, communication, digital and technological literacy, civic responsibility, and global awareness, are considered essential components of the twenty-first century skill set. Learning must include a human element, fostering an environment where new ideas are explored together, mistakes are made, solutions are discussed, and unconventional challenges are attempted. The primary goal of teaching at any educational level is to create meaningful change in the learner. To effectively transmit knowledge, teachers must use teaching techniques that align with specific objectives and competencies (Cruz, 2020). While many educators have relied on teacher-centred approaches to impart knowledge in recent decades, research in mathematics shows that traditional teaching methods are becoming increasingly irrelevant in the classrooms of the twenty-first century (Caramay & Cruz, 2023; Chris, 2016; Cruz, 2022).

Problem-based learning (PBL) is rapidly gaining recognition as a modern teaching technique due to its ability to enhance students' problem-solving skills. The primary aim of PBL is to support students in developing competencies such as communication, critical thinking, scientific knowledge and reasoning, decision-making, assessment, and evaluation. These skills are essential for fostering lifelong learning (Kay & Greenhill, 2010).

Based on the given description, using the PBL method while considering students' attitudes is expected to enhance their achievements, ability to make mathematical connections, and self-esteem in learning mathematics (Caramay & Cruz, 2023). Although numerous studies have explored its effectiveness among adult learners, there is limited research examining its impact on younger students. Therefore, it is essential to investigate the effectiveness of PBL and its impact on pupils' mathematical skill, attitudes and study habits. This study aims to answer the question: How effective is PBL in improving the problem-solving skills, attitudes, and study habits of Grade 6 pupils in the mathematics subject?

The general objective of the study is to analyse the effects of PBL on improving the problem-solving skills, attitudes and study habits in mathematics among Grade 6 pupils. Specifically, the study (i) assessed the level of problem-solving skills of Grade 6 pupils in mathematics before and after the implementation of PBL; (ii) assessed the attitudes of the Grade 6 pupils towards learning mathematics before and after the implementation PBL; and (iii) assessed the study habits of the Grade 6 pupils towards learning mathematics before and after the implementation of PBL.

Theoretical Framework

The theoretical foundation for analyzing the effects of PBL on students' problem-solving skills, attitudes, and study habits in mathematics is primarily rooted in constructivist learning theories, emphasizing active, inquiry-based, and self-regulated learning processes. PBL aligns with these principles by placing students at the center of their learning, encouraging them to engage in real-world problem-solving tasks that foster critical thinking and autonomy. This student-centered approach has been shown to improve not only problem-solving skills but also students' attitudes toward learning and their study habits (Savery, 2015; Golightly et al., 2023).

One of the key aspects of PBL is its alignment with constructivist principles, which propose that learners actively construct knowledge through engagement with their environment (Schunk & DiBenedetto, 2016). In the PBL context, students engage in complex, ill-structured problems that require them to apply prior knowledge, explore new concepts, and work collaboratively to construct solutions. Research has demonstrated that PBL enhances problem-solving skills by promoting deeper understanding and critical thinking, which are essential for solving real-world problems in mathematics (Ni'mah et al., 2024; Ahdhianto et al., 2020). Through iterative cycles of inquiry and reflection, students refine their strategies and develop greater cognitive flexibility (Ghani et al., 2021).

In terms of attitudes, PBL has been shown to have a positive impact on students' perceptions of mathematics. By making learning more relevant and engaging, PBL helps students develop a sense of competence and self-efficacy, which is linked to more positive attitudes toward mathematics (Sokolowski & Ansari, 2017). When students work on meaningful, real-world problems, they can better see the value of mathematics and its applications, which in turn fosters a more positive and persistent engagement with the subject (Chris, 2016). Studies suggest that students' attitudes towards mathematics improve when they experience success in problem-solving tasks and feel supported by their peers and instructors in collaborative learning environments (Savery, 2015; Dowker et al., 2019).

Furthermore, PBL has been found to promote the development of effective study habits by encouraging self-regulated learning. In PBL environments, students are typically given the autonomy to set goals, seek resources, and monitor their progress. This process helps cultivate important metacognitive skills, such as planning, self-reflection, and evaluation, which are critical for effective study habits (Schunk & Zimmerman, 2023). As students engage in self-directed learning, they develop strategies to manage their time and resources more efficiently, leading to improved academic outcomes (Rodniam & Suksuwanont, 2024). Moreover, regular engagement with PBL tasks can lead to the formation of productive, habitual study behaviors that contribute to long-term academic success (Ozdem-Yilmaz & Bilican, 2020; Mishra, 2022).

In conclusion, the theoretical framework underpinning PBL draws heavily on constructivist and self-regulated learning theories, which emphasize the active and autonomous nature of learning. These theories highlight the effectiveness of PBL in fostering problem-solving skills, improving attitudes toward mathematics, and promoting the development of positive study habits. Through its emphasis on real-world problem-solving, collaboration, and self-regulation, PBL provides a comprehensive approach to supporting students' mathematical learning and enhancing their overall academic success.

Materials and Methods

Research Design

This study used a quasi-experimental research design. A quasi-experimental research aims to establish a cause-and-effect relationship between an independent and dependent variable. This design aims to be an "intervention" in which the treatment – consisting of the elements of the program being evaluated – is tested to see how well it achieves its objectives, as measured by a pre-defined set of indicators (White & Sabarwal, 2014). Assignment to conditions (treatment versus no treatment or comparison) is by means of self-selection. In this study, the experimental group received the treatment implementation of PBL instruction and control group received direct instruction. This study used a quantitative method, including a survey questionnaire, post-test, and pretest to analyze the effects of PBL on pupils' problem-solving skills, attitudes, and study habits in mathematics.

Research Participants

The respondents of the study were the Grade 6 pupils of a Public School in Pila, Laguna, Philippines. All pupils who were selected for this study were distributed into two classes. The 40 pupils were equally divided depending on their scores in the pre-test. The scores were arranged from highest to lowest. The pupils then were grouped alternately by their scores to form two equally heterogeneous groups.

Two teaching methods were used in this study. The experimental group that received PBL instruction consisted of 20 pupils while the control group that received direct instruction consisted of 20 pupils. Before and after the treatment survey, a pretest and a post-test in mathematics were given to the two groups.

The respondents were composed of 52% male and 48% female. The age of the pupils varies since not all of them started studying at the same age. Most of them are 12 years old. In terms of their 3rd quarter achievement, most of them have grades between 85 and 89, which indicate a very satisfactory rating.

Instrumentation

Pretest and post-test in mathematics

The researcher developed the test, consisting of 20 multiple-choice questions (see Appendix A). Each question had one correct answer and 3 distracters. Content of the test was determined from the lecture materials and some mathematics books. The items focused on problems related to the volume of solids.

During the developmental stage of the test, the following procedures were followed: first, the instructional objectives were stated. Second, the books were carefully examined to find items which match the instructional objectives. Table of specification was also made to identify the easy, average, and difficult questions of the test (see Appendix B).

The tests were then shown to the experts in the field and all the comments were considered. These were the Master teachers and the school mathematics coordinator, who were asked to go through the questions and circle those that were not clear and had some grammatical or mathematical errors. Then, pilot testing was conducted with 20 pupils. After that, item analysis was made and removed the easy questions and revised the difficult ones. Finally, the revisions on the questionnaire were made before it was applied to both control and experimental groups.

Attitudes towards mathematics

To measure the attitudes of pupils towards mathematics, the Student's Attitudes Towards Mathematics (SATM) instrument by Guce and Talens (2013) was utilized. The instrument was anchored from the definition of attitudes towards mathematics given by Dowker et al. (2019). It consisted of 25 items to measure the attitudes of students towards mathematics. It was about openness to learning opportunities, self-concept, initiative, and independence in learning, informed acceptance of responsibility for ones's own learning, love of learning, creativity, positive orientation to the long run, and to use basic study skills in mathematics.

Each item had a five-point Likert format scale including "1 = strongly disagree", "2 = disagree", "3 = neither agree nor disagree", "4 = agree", "5 = strongly agree". To measure the instrument's reliability, a pilot test was conducted with 20 pupils. The result of Cronbach alpha (0.80) implies that the tool is reliable for research purposes.

Study habits of pupils

To measure the study habits of pupils in mathematics, an adopted instrument from the study of Balbalosa (2020) was utilized. The tool contains 10 items with a five-point Likert scale ranging from 1 for *always* and 5 for *never*. A pilot test was also conducted with 20 pupils to assess the reliability of the instrument. The value of Cronbach alpha is 0.85, which implies that the instrument is suitable for the study.

Designing the Problem-based Learning Lesson in Mathematics

The Analyse, Design, Develop, Implement, and Evaluate or ADDIE model was used to create the study's educational materials. However, there is no hard and fast linear progression through the steps in this order (Kurt, 2018).

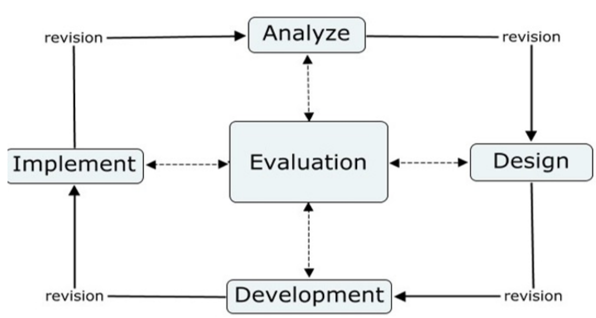

Figure 1: ADDIE Model (Kurt, 2018)

Analysis Phase

It is necessary to compile information about the pupils. Surveys on attitudes and study habits were carried out. Learners already know concepts connected to solid figures before the design phase. Numerous factors were taken into account, including the level of learning, the subject that the class required to cover, and the desired results. The educational goals were considered as well. After that, the specific methods and strategies were considered to find out if the activities will fit the theme. The number of hours for the teaching portion was examined, and resources for the content were plotted out.

Design Phase

Finding theories to incorporate into the teaching guide's formulation was a part of the design process. When creating the content, PBL is the main focus. Laudrisen (2012) identified six steps for implementing PBL.

At this stage, an outline was made, and learning design was the suitable technique of evaluation. The lecture adhered to the Department of Education's most essential learning competencies (MELCs). The DepEd-recommended activities and the standards and objectives were included in the lesson plan.

Development Phase

In order to create the teaching guide, genuine data, real findings, and reports were used. The information was collected through paper-based tests using pencils. Throughout the lesson, handouts and a power point presentation were used.

Implementation Phase

Prior to being deployed with a subset of 20 Grade 6 pupils, the developed instructional materials were pre-implemented with another group of pupils. At the beginning of the session, the teacher clarified some terms and concepts related to the volume of solid figures. This assisted in removing an early learning obstacle so that pupils could concentrate more on solving the difficulty they posed in relation to the subject. Secondly, the pupils defined the problem. The pupils used a variety of questions that addressed the topic to help them come up with a solution.

Evaluation Phase

A post-test was used to collect input (see Table 1).

1. Data Analysis

The mean percentage scores (MPS), Students' Attitudes Towards Mathematics (SATM) scores, and study habits scores were analysed using descriptive measures such as mean and standard deviations. The pretest and post-test were also analysed using descriptive measures such as mean scores.

Ethical Considerations

During the conduct of this research, the following ethical issues were taken into consideration:

Table 1: Problem-based learning versus Direct Instruction

Activity	Problem-based Learning	Direct Instruction
Motivation	A short story entitled "Helping Joan solve for the Volume" was given to the class.	A video clip regarding the topic was presented to the class.
Objectives	The objectives **which were** derived **from** the curriculum guide were presented to the class.	The objectives **which were** derived from the curriculum guide were presented to the class.
Review	Inquiry questions about solid figures were asked.	**Review** of concepts on solid **figures** was done through recitation.
Present the content	The pupils filled out the handouts with the clues **they got** from the story problem.	Definitions, concepts, and steps were directly given to the students. This was also when the **demonstration** by the teacher **was done**.
Guided Practice	**Curated** list of resources to be used in the activity **were** given in class.	The example of solid **figures** and how to solve for their volume were discussed.
Elicit performance (practice)	Presentation of **problem solving** for the volume of **solid** figures was conducted.	Other example of how to compute for the volume of the solid figures.
Provide feedback	Student consultation with their teacher about their answers was gathered.	An activity on solving the volume of solid figures was given to the students.
Assess performance	Each group discussed their answers.	The students had a recitation.
Enhance retention and transfer to the job	A post-test was given to the class. A post-test was given to the class.	

- Minimizing the risks of research to participants. In all aspects of the research – from recruiting participants to data collection, storage, and reporting results, risks to research participants were minimized.

- Protecting individuals who are members of groups that may be vulnerable to coercion or undue influence, as it relates to providing informed consent and assent.

- Consent of the participants was secured upon the conduct of the study.

Data privacy was strictly observed, and all information that the respondents provided was treated with utmost confidentiality.

- Ensuring that research subjects' participation was informed and voluntary.
- Respondents who participated in this study were on a voluntary basis. A letter to respondents was secured first asking for their assent to be part of the study. For the respondents, they remained anonymous in the manuscript.

2. Results and Discussions

Pupils' level of problem-solving skills in mathematics before and after the implementation of PBL

The mean scores between the pre-test and post-test results for pupils in the experimental group and control group are shown in Table 2. Pupils in control groups received direct instruction, while pupils in experimental groups received PBL instruction. The pre-test mean score for the respondents in the experimental group was 5.49, while the post-test mean was 8.85, indicating a 51% improvement in problem-solving abilities. In contrast, the respondents from the control group obtained a mean of 5.25 in the pre-test and 6.30 in the post-test, reflecting only a 22% increase in problem-solving skills. This demonstrates that the control group's mean was higher than the experimental group's during the pre-test, whereas the experimental group outperformed than the control group in the post-test. It implies that PBL instruction contributes to pupils' performance in math.

Table 2: Problem-solving skills using pre-test and post-test

Groups	**Pre-test**		**Post-test**	
	Mean	**SD**	**Mean**	**SD**
PBL	5.49	2.60	8.85	3.65
Direct Instruction	5.25	3.45	6.30	2.83

The pre-post knowledge test was employed to examine the assumptions made by pupils on PBL. The results revealed that the experimental group's mean assessment scale scores were higher than those of the control group. This affirms how PBL enhances students' understanding of mathematical concepts and problem-solving strategies by engaging them with challenging, open-ended questions that encourage inquiry, critical thinking, and self-directed learning (Golightly et al., 2023; Ni'mah et al., 2024). The results suggest that PBL, by providing challenging, collaborative problem-solving experiences, effectively supports cognitive development as envisioned by both Piaget and Vygotsky, leading to significant improvements in students' problem-solving skills in mathematics.

In addition, Zhu and Chiu (2019) contrasted the results of the study's PBL instruction techniques with those of the control group, which received traditional approach. Between the children in the experimental group and the control group, there was a significant difference that favoured the experimental group. PBL improved students' math performance, which contributed to the information's longevity.

The findings of the study by Wigfield et al. (2016) agreed with the association between achievement score and student achievement level. They discovered that students' background performance levels, such as their problem-solving and critical thinking abilities, have a significant impact on their degree of achievement. Additionally, prior knowledge – the key component of PBL – was the best predictor of success.

The findings reveal a distinction between the students' post-test performance after being exposed to PBL and the traditional instructional technique of teaching. Thus, PBL can develop analytical abilities by assessing and drawing conclusions from data (Wigfield et al., 2016). Students work through the inquiry process while solving issues in a classroom setting that is incredibly typical for PBL. Teachers support their students' exploration of alternatives, invention of alternate solutions, collaboration with other students, undertaking of ideas and hypotheses, revision of their thinking, and presentation of their best solutions when they engage in PBL. Students have the chance to engage in exploration together and draw findings that matter through hands-on activities (Wigfield et al., 2016). According to Lipnevich et al.'s (2016) study, which used an experimental pre- and post-test design and compared the outcomes of the PBL group with those of the control group, PBL has had a significant impact on academic achievement.

Pupils' attitudes towards mathematics before and after the implementation of PBL

Top five student attitudes toward mathematics

Table 3 presents the pre-survey results of pupil's attitudes towards learning mathematics. The table shows that the respondents, top five attitudes toward mathematics are: *"I want to develop my mathematics skills"* with a mean of 4.78, *"Math helps people to make good decisions"* with a mean of 4.52, *"Math improves my thinking capacity"* with a mean of 4.52, *"Knowing math will help me earn a living"* with a mean of 3.64, and *"I will need math for my future work."* with a mean of 3.60.

Five lowest-rated attitudes toward mathematics among students

Five lowest-rated attitudes toward mathematics are: *"Mathematics does not scare me at all"* with a mean of 2.20, *"I have confidence in taking math test"* with a mean of 2.92, *"I can solve math problem within a given time"* with a mean of 2.98, *"I am able to solve math problems without difficulty"* with a mean of 3.22, and *"I get nervous when math teacher is in class"* with a mean of 3.32.

The increase in pupils' positive attitudes toward mathematics, as evidenced by the rise in post-survey scores, can be explained through Bandura's social learning theory. PBL likely facilitated motivation and self-efficacy by providing mastery experiences and opportunities for observational learning, leading to a more positive outlook on mathematics.

Likewise, the observed improvement in pupils' attitudes towards mathematics after the implementation of PBL suggests that PBL may help shift students'

Table 3: Pre-survey results of pupils' attitudes toward learning mathematics

Attitudes towards Mathematics	Mean	Verbal Interpretation	Rank
Working math makes me nervous.	4.05	Tend to agree	5
I get a sinking feeling when I think of learning math.	4.08	Tend to agree	4
Learning math is very frustrating.	3.48	Tend to neither agree nor disagree	12
I feel insecure about asking math questions in class.	3.53	Tend to agree	11
I get nervous when the math teacher is in class.	3.33	Tend to neither agree nor disagree	14
Math does not scare me at all.	2.20	Tend to disagree	21
I have self-confidence in learning math.	3.40	Tend to neither agree nor disagree	12
I have confidence in taking a math test.	2.93	Tend to neither agree nor disagree	19
I can solve math problems within a given time.	2.98	Tend to neither agree nor disagree	17
I am able to solve math problems without difficulty.	3.23	Tend to neither agree nor disagree	15
I have confidence in asking math questions in class.	3.68	Tend to agree	4
I am able to answer math questions in class.	3.35	Tend to neither agree nor disagree	11
I enjoy doing math.	3.23	Tend to neither agree nor disagree	13
Math word problems fascinate me.	2.98	Tend to neither agree nor disagree	13
I look forward to a math class.	3.25	Tend to neither agree nor disagree	12
Math is very interesting to me.	3.48	Tend to agree	10
I enjoy learning math with my friends.	3.65	Tend to agree	5
I feel comfortable working math problems.	3.33	Tend to neither agree nor disagree	9
Math is important in everyday life.	3.60	Tend to agree	6
I want to develop my math skill.	4.78	Tend to strongly agree	1
Math is a very necessary subject.	3.63	Tend to agree	4
Knowing math will help me earn a living.	3.68	Tend to agree	3
I will need math for my future work.	3.60	Tend to agree	3
Math helps people to make good decisions.	4.53	Tend to strongly agree	1
Math improves my thinking capacity.	4.53	Tend to agree	1
General weighted mean	**3.54**	**Tend to agree**	

emotional and cognitive perspectives. By presenting mathematics as relevant to real-world problems and fostering a collaborative, inquiry-based learning environment, PBL likely increases students' sense of competence and enjoyment, which Dowker et al. (2019) identify as key to developing positive attitudes. This shift could lead to greater engagement and a more positive view of mathematics as both an enjoyable and essential subject.

Depending on the importance of the lesson's benefits to the pupils' everyday lives, the teacher's role in the lesson, and the approach used to teach it, the pupils' attitudes toward mathematics vary. Most pupils have a sincere desire to comprehend mathematics, but one obstacle to their pursuit of it is their lack of drive.

A wide range of science perceptions, attitudes, and values, as well as people's desire in pursuing possible professions in mathematics, are all influenced by attitudes, which is a somewhat more voluntary construct (Savery, 2015). Sokolowski and Ansari (2017) assert that students' attitudes improved once they sensed a connection to the teacher and the importance of the subject. According to studies in this field, students prefer learning experiences that emphasize the application of science through problem-based learning, discussion, and activity-based practical work (Chris, 2016).

The study by Guinocor et al. (2020), which examined the impact of PBL on student attitudes according to educational level, lends confirmation to this. According to the data, PBL's impact on students' attitudes is consistent across all educational levels. In other words, the effect sizes achieved from the adoption of PBL in primary school, middle school, high school, and higher education levels are all equal. According to a study by MacDonald (2014), the use of PBL at the primary, secondary, or instructional levels had no impact on students' attitudes toward their classes. In contrast, Bransford (2015) compared the attitudes of preschool students in the first, second, third, and fourth grades toward PBL. The investigation revealed that PBL has little positive influence on students' attitudes. It suggests that PBL is efficient at assisting learners in developing a favourable attitude toward subjects.

Table 4 presents the differences between the pre-survey and post-survey on pupils' attitudes towards mathematics after the implementation of PBL. The mean of the pre-survey is 3.67, while the mean of the post-survey is 3.92. Although the means differ slightly, both fall within the same verbal interpretation, which indicates a general tendency to agree.

Table 4: Pre-survey and post-survey results of attitudes towards mathematics

Attitudes toward Mathematics	Mean	Verbal Interpretation
Before Implementation of Problem-Based Learning	**3.67**	**Tend to Agree**
After Implementation of Problem-Based Learning	**3.92**	**Tend to Agree**

The pupils appreciated the session because it used PBL, even though it had a self-earning section where they had to complete an activity. It increases their desire to learn and research a certain subject in order to participate in group projects. Since everyone had a role to play, they felt as though they truly belonged to a certain group. Dostál (2015) asserts that students' attitudes improved after they sensed a connection to the teacher and the importance of the subject. According to studies in this field, students prefer learning experiences that emphasize the relevance of science through problem-based learning, conversation, and activity-based practical practice. This collaborative environment positively influences students' attitudes toward mathematics by boosting their engagement and reducing their anxiety about tackling difficult mathematical tasks (Ghani et al., 2021).

According to the pupils' comments, problem-based learning is a student-centred approach that enables them to build knowledge by actively working and debating in groups. They claimed that rather than providing comprehensive information and solutions, teachers have a responsibility to offer direction. They stressed that students were active learners by asking questions, conducting searches, having discussions, and exploring for knowledge from various sources. The PBL situations also motivated and assisted students' learning.

According to Yasar (2014), students' attitudes toward PBL and, as a result, their interests in mathematics, were usually positive. In contrast to conventional teaching, some studies in the literature also contend that PBL has a positive effect on students' attitudes (Martinez & Mcgrath, 2014), while others contend that it has no effect at all (positively or negatively). Therefore, it seems that individual research compares PBL to traditional teaching and examining the effects on students' attitudes toward subjects.

Pupils' study habits in mathematics before and after the implementation of PBL

Top five habits pupils practice in learning mathematics

Table 5 presents the pre-survey results of pupils' study habits towards learning mathematics. The table shows that respondents' top five habits in mathematics are: *"I seek clarification whenever if don't understand my lessons"* with a mean of 4.15, *"I see to it that I give myself enough breaks during study period"* with a mean of 4.05, *"I study and prepare for quizzes and tests"* with a mean of 3.82, *"I have a specific place of study at home which I keep clean and orderly"*, with a mean of 3.82, and *"I do my assignments regularly"* with a mean of 3.65.

Bottom five habits pupils practice in mathematics

The bottom five habits are: *"I make a list of things to study"* with a mean of 3.18, *"I am willing to do the work I do not enjoy because I see it as important"* with a mean of 3.18, *"I spend less time with my friends during school days to concentrate more on my studies"* with a mean of 3.28, *"I spend my vacant time in doing assignments or studying my lessons"* with a mean of 3.40, and *"I prefer finishing my studying and my assignments first before watching any television program"* with a mean of 3.50.

According to Ozdem-Yilmaz and Bilican (2020), the term "habit" refers to patterns of repeating activities that people engage in habitually without thinking about it. When a person repeatedly completes a task over time, again and over, it

Table 5: Pre-survey results of pupils' study habits in mathematics

Study habits in mathematics	**Mean**	**Verbal interpretation**	**Rank**
I do my assignments regularly.	3.80	Tend to do it often	5
I exert more effort when I do difficult assignments.	3.63	Tend to do it often	7
I spend my vacant time in doing assignments or studying my lessons.	3.40	Tend to do it sometimes	12
I study the lessons I missed if I was absent from the class.	3.60	Tend to do it often	8
I study and prepare for quizzes and tests.	3.85	Tend to do it often	4
I study harder to improve my performance when I get low grades.	3.53	Tend to do it often	9
I spend less time with my friends during school days to concentrate more on my studies.	3.28	Tend to do it sometimes	13
I prefer finishing my studying and my assignments first before watching any television program.	3.50	Tend to do it often	10
I make sure that extracurricular activities do not interfere with my studies.	3.65	Tend to do it often	6
I have a specific place of study at home which I keep clean and orderly.	3.83	Tend to do it often	3
I am willing to do the work I do not enjoy because I see it as important.	3.18	Tend to do it sometimes	14
I make a list of things to study.	3.18	Tend to do it sometimes	15
I make sure that I give myself enough breaks during study period.	4.05	Tend to do it often	2
I seek clarification whenever I don't understand my lessons.	4.15	Tend to do it often	1
I go to tutorial classes to improve myself.	3.45	Tend to do it sometimes	11
General weighted mean	**3.60**	**Tend to do it often**	

results in the creation of habits, which eventually become automatic in nature as the behaviour changes from being motivated deliberately to being more routine. Because habits are automatic in nature, they play a crucial part in the development of study habits among students, which is one of the key factors in determining a student's academic achievement (Mishra, 2022).

Students that have good study habits find learning more pleasant and pleasurable and their courses easier to understand. A student's ability to learn and perform academically will be improved by having strong study habits. Some students may have bad study habits that annoy them and make studying difficult for them (Sokolowski & Ansari, 2017).

Effective study habits have been the subject of numerous studies by scholars including Kung and Lee (2016). They contend that students' academic achievement and their study habits are closely related. A student with one set of study habits will perform differently than a student with another set of habits. It is thought that students who do not have efficient and effective study methods would be built on shaky ground and would subsequently have weak foundations.

Everyone's academic journey should begin with the development of healthy study habits. This will pave the way for numerous long-term beneficial life skills to be learned. It develops into enhancing traits like discipline, productivity, and general success and goes well beyond simply receiving good marks (Uchida & Mori, 2018).

Table 6 presents the differences between the pre-survey and post-survey on pupils' study habits in mathematics after the implementation of problem-based learning. The mean of the pre-survey is 3.49, while the mean of the post-survey is 3.95. Although the means differ slighly, both fall within the same verbal interpretation, which indicates a general tendency to agree.

Table 6: Pre-survey and post-survey results of study habits in mathematics

Study habits in mathematics	**Mean**	**Verbal interpretation**
Before Implementation of Problem-Based Learning	3.49	Tend to do it often
After Implementation of Problem-Based Learning	3.95	Tend to do it often

Even though the class had parts where pupils needed to conduct research, PBL was used to make the lesson engaging for the pupils. It increases their desire to learn and research a certain subject in order to participate in group projects. The pupils experienced a sense of belonging.

Study methods are known as study habits and can be systematic, effective, or ineffective (Balbalosa, 2020). Study habits, as defined by Dostál (2015), are tendencies that students have acquired over time toward independent reading. He asserts that good study habits are the key to academic success. Effective study methods are associated with improved academic success, while ineffective study methods are associated with academic failure.

Study habits can have either favourable or bad consequences on academic performance because of their close connection to it, claim Sokolowski and Ansari (2017). Learning how to study more effectively – rather than more laboriously – is the key. As a person moves forward in their schooling, this holds increasingly true. If a person does not know how to study smarter, there will not be enough hours in the day to get all the studying done in college. An hour or two of studying each day is typically adequate to get through high school with passing grades.

When students tackle and solve challenging tasks, they cultivate a positive attitude toward learning and persistence in mathematics, which in turn strengthens their confidence in their mathematical abilities. These mastery experiences also foster good study habits, teaching students to approach complex assignments systematically and apply metacognitive strategies such as reflection and self-monitoring (Schunk & DiBenedetto, 2016). Problem-based learning (PBL) encourages students to take control of their learning by setting goals, seeking resources, and assessing their progress (Schunk & Zimmerman, 2023). This autonomy promotes effective study habits and a lifelong enthusiasm for mathematics. Research by Rodniam and Suksuwanont (2024) shows that PBL fosters active learning and helps students develop metacognitive skills essential for establishing productive study habits.

3. Conclusions

This paper explores the effectiveness of PBL in enhancing problem-solving skills, attitudes, and study habits in mathematics education. PBL is a student-centred approach that emphasizes active learning and critical thinking. Prior to PBL implementation, the pupils had low problem-solving skills in terms of mean percentage score. The pupils in both the control and experimental groups have a positive attitude towards mathematics. The problem-solving skills of both the experimental and control groups improved. However, as shown in the results, of the experimental group achieved higher means than the control group. Meanwhile, the pre-survey and post-survey on study habits have the same verbal interpretation. The PBL instruction in the experimental group caused a better understanding of topics in mathematics than the direct instruction in the control group. The pupils taught by PBL instruction were more motivated to learn mathematics than their counterparts taught by the direct instruction method.

With these, PBL instruction must be promoted in teaching mathematics rather than teaching students using plain lecture methods. It is very helpful with developing the problem-solving skills, attitudes, and study habits since one of the goals of K-12 education is for lifelong learning of the pupils.

Using PBL in the new normal setting of conducting classes was also effective. The PBL module can be used in blended learning since it can be designed for synchronous and asynchronous classes. The pupils taught by PBL strategy were more inclined to take responsibility of their own learning than those taught by the conventional strategy.

The evidence provided in this study support the implementation of PBL in mathematics education. By using PBL, educators may provide children vital abilities and attitudes that go well beyond the mathematics classroom, preparing them for success in an increasingly complex and problem-solving-dependent world.

In relation to the limitations of this study, it is suggested that the study be done at the start of the school year. In this time, the pupils will only get to encounter the teacher for the first time and cannot have an influence on their attitudes. It is also recommended that the attitudes be analyzed through consistent observations similarly. Students Attitudes Questionnaire Towards Mathematics measures only their attitudes as perceived by them. With continuous monitoring, real actions are recognized. Other factors that influence learning mathematics may additionally be considered.

Additional research on PBL in elementary school may be transported out on other subjects such as science, English and social studies, etc. A related study can be made since mathematics is a broad subject that cannot be fully developed in a short period of time. Succeeding study may be conducted in a longer duration to obtain significant results. The use of random selection of respondents is also suggested to be able to use inferential analysis for broader implication of the study. The use of other complicated topics in mathematics is also recommended. Factors such as age, sex, and academic status need to be studied deeply in order to see the relation of this factors to learning with PBL application.

PBL has the potential to enhance problem-solving skills, attitudes, and study habits in mathematics education. By aligning with constructivist learning theories and emphasizing real-world problem-solving, PBL can transform mathematics classrooms into dynamic and engaging learning environments. While challenges may exist, with proper support and commitment, PBL can help learners build the critical skills needed for success in mathematics and beyond.

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Appendix A

Finding the Volume of Solid Figures
Pre-Test/Post-Test

1. The ____________ of a solid figure refers to the amount of space inside it.
   A. volume
   B. area
   C. surface area
   D. circumference
2. Which of the following statements correctly describe the volume of prisms and pyramids with the same dimensions?
   A. The volume of a pyramid is one-third of the volume of a prism.
   B. The volume of a pyramid is one-fourth of the volume of a prism.
   C. The volume of a pyramid is one-third greater than the volume of a prism.
   D. The volumes of a pyramid and prism are the same because their bases are the same.
3. A ____________ is a solid three-dimensional figure, which has 6 square faces, 8 vertices and 12 edges. It is also said to be a regular hexahedron.
   A. sphere
   B. cube
   C. cylinder
   D. rectangular prism
4. A ____________ is a three-dimensional object with rectangles as all of its faces. If all the faces of the prism are squares, then the rectangular prism is a cube.
   A. cube
   B. sphere
   C. rectangular prism
   D. cone
5. A ____________ has two circular bases that are congruent and parallel.

A. cylinder
B. cube
C. pyramid
D. sphere

6. A ___________ is a closed figure with a circular base and a single vertex.

A. sphere
B. cone
C. cube
D. rectangular pyramid

7. A ___________ is the set of all points in space that are the same distance from a given point called the center.

A. sphere
B. cone
C. cube
D. rectangular pyramid

8. A cylinder and a cone have the same radius and height. How will you compare the volume of the cone to the volume of the cylinder?

A. The volume of the cone is two-thirds the volume of the cylinder.
B. The volume of the cone is four-thirds the volume of the cylinder.
C. The volume of the cone is one-third the volume of the cylinder.
D. The relationship of the volumes of the cylinder and cone cannot be determined.

9. Which of the following statements correctly describe the volume of prisms and pyramids with the same dimensions?

A. The volume of a pyramid is one-third of the volume of a prism.
B. The volume of a pyramid is one-fourth of the volume of a prism.
C. The volume of a pyramid is one-third greater than the volume of a prism.
D. The volumes of a pyramid and prism are the same because their bases are the same.

10. If the cone has a height of 10 cm and a diameter of 5 cm, what is its volume?

A. 65.42 cm^3
B. 66.42 cm^3
C. 67.42 cm^3

D. 68.42 cm^3

11. A spherical tank for natural gas has a radius of 7 meters. About how many cubic meters of natural gas can it hold?

    A. 1,437.03 m^3
    B. 1,436.03 m^3
    C. 1,435.03 m^3
    D. 1,434.03 m^3

12. A rectangular pool has a length of 24 meters, a width of 18 meters, and a height of 2 meters. How much water can it hold?

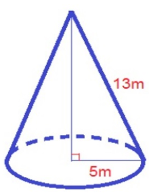
    A. 860 m^3
    B. 862 m^3
    C. 864 m^3
    D. 866 m^3

13. A cylindrical tank has a height of 6 meters and a diameter of 4 meters. Find the volume of that cylindrical tank.

    A. 75.36 m^3
    B. 65.36 m^3
    C. 55.36 m^3
    D. 45.36 m^3

14. Xavier has a chocolate box whose length is 15 cm, height of 9 cm, and width of 7 cm. Find the volume of the box.

    A. 645 cm^3
    B. 745 cm^3
    C. 845 cm^3
    D. 945 cm^3



15. Find the volume of the cone.

    A. 340.17 m^3
    B. 314.23 m^3
    C. 414.23 m^3
    D. 540.23 m^3

16. The volume of a right circular cone A is 225 cubic inches. What is the volume, in cubic inches, of a right circular cone with twice the radius and twice the height of cone A?

    A. 450

B. 900

C. 1,800

D. 3,600

17. Peter made a solid shape from 12 blocks, in which 8 are small blocks, and 4 are big blocks. If the small block is made up of 3-inch cubes and the big block is made up of 5-inch cubes, what is the solid shape's total volume?

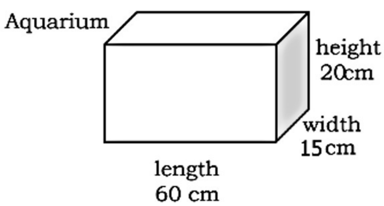
A. 308 m^3

B. 716 m^3

C. 864 m^3

D. 1,108 m^3

18. Allan keeps a tropical fish. His aquarium is 60 cm long, 15 cm wide and 20 cm high. Each fish needs 20 cubic cm of water. Solve for the maximum number of fish that he can keep in the aquarium.



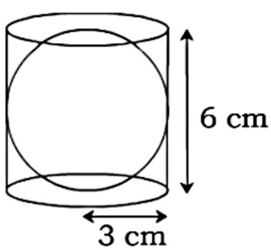
A. 500 fish

B. 600 fish

C. 800 fish

D. 900 fish

19. A sphere with a radius of 3 cm fits inside a cylinder with a height of 6 cm, as shown. Find the volume that is inside the cylinder but outside the sphere. (Hint: The volume of the cylinder minus the volume of the sphere)



A. 56.25 cm^3

B. 66.25 cm^3

C. 76.25 cm^3

D. 46.25 cm^3

20. A cylindrical tank has a diameter of 24 dm and a height of 30 dm. How many liters of water can it hold when full? ($1\ dm^3 = 1$ L)

A. 13,564.8 dm^3

B. 10,345 dm^3

C. 11,234 dm^3

D. 10,355 dm^3

Appendix B

Table of Specification for First Summative Test in Mathematics 6: Finding the Volume of Solids

A	B	C		D		E	
Instructional Objectives	**Number of Test Items**	**Easy (40%)**		**Average (35%)**		**Difficult (25%)**	
		Test Placement	**%**	**Test Placement**	**%**	**Test Placement**	**%**
Identify the different solid figures.	4	1-4	20%				
Describe the different solid figures.	4	5-8	20%				
Find the volume of cylinders, pyramids, cones, and spheres.	7			9-15	30%		
Solve routine and non-routine problems involving volumes of solids.	5					16-20	25%
Total	**20**	**8**	**40%**	**7**	**35%**	**5**	**25%**

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