



Effect of Problem-based Learning on Mathematical Problem-solving Ability of Sixth-Grade Students in Leshan Primary School

Yu Yuhua¹, Danucha Saleewong², and Kanreutai Klangphahol³

¹Master student, Curriculum and Instruction Program, Valaya Alongkorn Rajabhat University under the Royal Patronage Pathum Thani Province, Thailand

^{2,3} Lecturer, Curriculum and Instruction Program, Valaya Alongkorn Rajabhat University under the Royal Patronage Pathum Thani Province, Thailand

E-mail: 553414534@qq.com, ORCID ID: <https://orcid.org/0009-0006-5809-4400>

E-mail: Danucha@vru.ac.th, ORCID ID: <https://orcid.org/0000-0001-8145-6170>

E-mail: Kanreutai@vru.ac.th, ORCID ID: <https://orcid.org/0009-0003-2294-6390>

Received 21/03/2024

Revised 05/04/2024

Accepted 20/04/2024

Abstract

Background and Aim: In the 21st century, Mathematics is a science that plays an important role in learners' education and life. Science helps humans in the analysis of problems and surrounding circumstances that could guide them in prediction, planning, and finding the most appropriate way to solve the problems. The objective of this study was to (1) compare the students' mathematical problem-solving ability before and after learning through Using Problem-based Learning, (2) compare the mathematical problem-solving ability after learning through Problem-based learning with the determined criterion set at 70%, and (3) assess the significance level of students' satisfaction after learning through Problem-based Learning

Materials and Methods: This study used a cluster sampling method with 30 students as the sample. The research tools are (1) a lesson plan, (2) multiple choice for Mathematical problem-solving ability, and (3) a satisfaction questionnaire. Conduct pre-test and post-test on the sample using academic performance papers, and analyze the mean, standard deviation, and t-test.

Results: Results found that (1) the student's mathematical problem-solving ability after learning through problem-based learning than before at a statistically significant level of .05. (2) The students' mathematical problem-solving ability after learning through problem-based learning was higher than the determined criterion of 70% at a .05 statistical significance level. (3) The students' satisfaction after learning through problem-based learning was at a higher level.

Conclusion: Through the classroom practice of problem-based learning, the learning efficiency is improved and the individual learning needs of students are met. It helps to improve students' academic performance and win students' popularity.

Keywords: Problem-based learning; Mathematical problem-solving ability

Introduction

Mathematics is a science that plays an important role in learners' education and life in the 21st century. Science helps humans in the analysis of problems and surrounding circumstances that could guide them in prediction, planning, and finding the most appropriate way to solve the problems (Erik, 2007). Mathematics is an integral part of a range of subjects that play an important role in education. In April 1980, in the name of the National Federation of Mathematics Teachers, a document titled "Platform for Action - An Agenda for Mathematics Education in the 1980s" was released, which for the first time put problem-solving at the core of middle school mathematics in the 1980s. At the Fourth International Mathematics Conference in August 1980, the American Association of Mathematics Teachers put forward eight recommendations of the middle school mathematics education action Plan in the 1980s, pointing out that the focus of the middle school mathematics education reform in the 1980s was to cultivate students' problem-solving ability, which is a sign of the strength to measure the level of individual and national mathematics.

After the 21st century, "Problem-solving" as a new teaching strategy has become a hot topic in the reform of global mathematics education. It can be said that the thought and practice of "problem-solving" have influenced the process of mathematics education and promoted the reform of the mathematics curriculum. Problem-solving is the focus of the mathematics curriculum, and improving students' ability to



solve Mathematical problems is an important task of mathematics teaching. Through the teaching of problem-solving, students can gain rich experience in Mathematical activities and deepen their understanding of the essence of Mathematical knowledge and thought methods. In the process of problem-solving teaching, students' independent thinking and mutual cooperation ability among students will be improved accordingly (Marra et al., 2014).

Nie (2023) said: "Mathematics comes from reality, and must be rooted in reality and applied to reality." Mathematics is a very important subject in primary school, and it is also the basis of learning other subjects. It is one of the most suitable subjects to cultivate and stimulate students' problem-solving ability. The process of problem-solving, can improve the subjective initiative of learning, cultivate the habit of cooperation, experience a variety of learning experiences, feel the fun of learning, and cultivate students' ability to find, propose, analyze, and solve Mathematical problems. To cultivate students' understanding of problems is the core of mathematics teaching in China's compulsory education stage: "To experience the connection between Mathematical knowledge, mathematics, and other disciplines, mathematics, and life, to use Mathematical thinking methods to think, and to improve students' ability to discover and raise problems, analyze and solve problems." (Ministry of Education of the People's Republic of China, 2011). In 2016, the Ministry of Education of the People's Republic of China pointed out in the Guiding Opinions of the Ministry of Education on Deepening the Reform of Education and Teaching in Institutions of Higher Learning directly under the Central Government: In terms of the relationship between teaching and learning, it is necessary to establish the concept that students are the main body of teaching activities, and pay more attention to cultivating students' independent learning ability and innovative spirit; The teaching reform is to change the teaching method, let the students become the main body of the classroom, fully mobilize the enthusiasm of the students, improve the innovative consciousness of the students, change the traditional teaching method, reform the teaching method, and widely carry out the heuristic, discussion and participatory teaching. Let students take the initiative to learn, and improve independent learning ability and academic performance. (Ministry of Education of the People's Republic of China, 2016)

In 2019, the Ministry of Education issued the Opinions on Deepening the Reform of Undergraduate Education and Teaching and Comprehensively Improving the Quality of Talent Training. It is clearly pointed out that it is necessary to enhance academic challenges, strengthen the quality requirements of talent training programs, teaching processes, and teaching assessment, scientifically and reasonably set the total number of credits and courses, increase students' learning time, improve their academic performance, and guide students to read more, think deeply, ask more questions and practice frequently. (Ministry of Education of the People's Republic of China, 2019)

In summary, this research study introduces problem-based learning (PBL) into mathematics problem-solving courses to improve students' mathematics problem-solving ability, students' achievements, improve teachers' educational concepts, and promote teaching method reform, establish a learner-centered educational environment, and provide learning conditions that can cultivate students' thinking ability, creativity and problem-solving ability. This integration reflects a commitment to contemporary educational principles and aims to empower students for success in real-world challenges.

Research questions

1. How is students' mathematical problem-solving ability before and after learning through problem-based learning?
2. How is the mathematical problem-solving ability of students after learning through problem-based learning compared with the criterion set at 70%?
3. What is the student's satisfaction level after learning through problem-based learning?

Objectives

1. To compare the students' mathematical problem-solving ability before and after learning through using problem-based learning.
2. To compare the mathematical problem-solving ability after learning through problem-based learning with the determined criterion set at 70%.
3. To assess the students' satisfaction after learning through problem-based learning.

Literature review

Problem-based learning (PBL) originated in North American medical education in the 1960s. Problem-based learning is a new problem-oriented teaching method. Traditional teaching methods are often based on teachers' teaching and students' learning. This approach often limits students' ability to think independently and innovate. In contrast, problem-based learning is a student-centered approach.

David (2011) believes that problem-based learning is a teaching method of discussion and learning centered on practical problems. This teaching method can stimulate students' independent learning ability and exercise students' ability to solve practical problems. Therefore, students can accurately position themselves and find the gap in achieving the goal, to achieve the teaching purpose of learning. Problem-based teaching puts learning in a meaningful and real problem situation, takes problems as the starting point of learning, and conducts learning around real and meaningful problems. Through group cooperation, in the process of exploring, analyzing, and finally solving problems, learning the scientific knowledge behind the problems, forming the ability to solve problems, and cultivating the learning ability is a new teaching strategy. Problem-based learning is to place learning in a meaningful and real problem situation, take the problem as the starting point of learning, and learn about the real and meaningful problem. Through group cooperation, in the process of exploring, analyzing, and finally solving problems, learning the scientific knowledge behind the problems, forming the ability to solve problems, and cultivating the learning ability is a new teaching strategy.

There have been many scholars putting forward various definitions of Problem-based learning. For instance, Barrett and Moore (2010) refer to Problem-based learning as a type of innovative instructional methodology that serves to improve the student's learning process. Marra et al., (2014) have the same belief in the definition of Problem-based learning, which stated that PBL is a type of learning method that can enable the students to acquire knowledge effectively after going through authentic problem-solving. Therefore, it is indicated that the problem involved in such a process provides a chance for the students to be cultivated as creative and innovative students (Simanjuntak et al., 2021).

To sum up, problem-based learning is a problem-oriented teaching method that emphasizes students' accumulation of knowledge and skills in the process of problem-solving, and the teaching method of realistic problems. This teaching method aims to cultivate students' spirit of inquiry, critical thinking, and self-directed learning, enabling them to tackle unknown challenges and solve practical problems.

Mathematical problem-solving ability refers to our ability to solve and innovate when facing mathematical problems. Mathematical problem-solving ability includes problem analysis, problem transformation, problem-solving, and problem verification. When solving mathematical problems, we need to be able to accurately understand the requirements of the problem, translate the problem into mathematical language, use appropriate mathematical methods and skills to solve the problem and verify the results. Problem-solving is an important skill in mathematics education (Rahman & Ahmar, 2016). It is relevant to the use of mathematical thinking, which is essential in solving both real-world and mathematical problems (Demitra & Sarjoko, 2018). In addition, Zulkarnain et al. (2021) suggest increasing the mathematical problem-solving of students as a foundation for developing their thinking processes. The mathematical problem-solving process allows students to develop their ability to adjust and modify their approach to new problem situations. A learning approach that develops students' mathematical thinking by providing problems that need to be analyzed, either individually or in groups, to generate solutions, will enable students to improve their mathematical performance (Rudibyni et al., 2020). Solving mathematics

problems effectively requires higher-order thinking skills and an understanding of the mathematical context (Noor et al., 2020).

It is an important task to cultivate students' problem-solving ability in primary school mathematics education. By providing a variety of questions, guiding inquiry and discovery, focusing on collaborative learning, and providing appropriate challenges, students can develop and enhance their problem-solving skills. The evaluation of problem-solving ability requires comprehensive consideration of students' thinking process and problem-solving results, which can be achieved through observation and record, work display, competition organization, and case analysis. Through continuous training and evaluation, we can help students develop good problem-solving habits and lay a solid foundation for their future study and life in mathematics.

In short, improving students' ability to solve mathematical problems mainly includes the following three important abilities: (Zong, 2020; Wei, 2020; Kang, 2020; Chimmalee & Anupan, 2022; Ninnuan, 2022)

1. Reading and analysis ability
2. Mathematical divergent thinking ability
3. Mathematical operation process test ability

Conceptual Framework

The conceptual framework of this thesis was composed of three variables in which one independent variable is Problem-based Learning, (Arends, 2008; Sudarman, 2007; Liu, 2016) and the other two dependent variables are mathematical problem-solving ability (Zong, 2020; Wei, 2020; Kang, 2020; Chimmalee & Anupan, 2022; Ninnuan, 2022) and the Students' satisfaction.

Independent Variable Dependent Variables

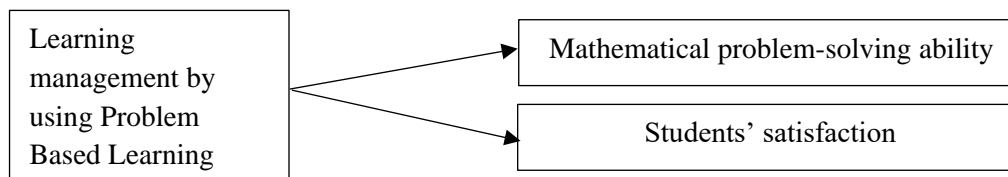


Figure 1 Research Conceptual Framework

Methodology

1. Population and sample

1.1 The population in this study was 150 students (5 classes) in Leshan Primary School.

1.2 The sample of this study was 30 students in Grade 6 of Leshan Primary School (1 class), which was derived from the cluster random sampling method.

2. Research instruments

Research instruments were the tools for collecting data. The research instruments which were used in this study were:

2.1 Lesson plan

There were 5 lesson plans allotted with 15 hours of teaching Mathematical problem-solving ability. The lesson plans of using problem-based learning on Mathematical problem-solving ability. The researcher created the evaluation form of lesson plans.



Table 1 Lesson plan

Lesson	Topic	Time Duration
1	Discount -Mathematical Reading and analysis ability	3 hours
2	The quantitative relationship of fractional multiplication word problems - Mathematical Reading and Analysis ability	3 hours
3	The formula for the area of a circle - Mathematical divergent thinking ability	3 hours
4	Trapezoidal area calculation formula - Mathematical divergent thinking ability	3 hours
5	Score four mixed operation - Mathematical operation process test ability	3 hours

2.1.1 An expert group composed of five experts evaluates the evaluation form. After collecting data, analyze the collected data to determine the appropriateness and consistency of the lesson plans. If the average score of appropriateness and consistency assessed by a group of experts is higher than 3.51, it means that the components of the lesson plans have good appropriateness quality and internal consistency. After obtaining the expert evaluation results, the developed teaching model was revised and improved according to the expert's suggestions.

2.1.2 It was found that the mean score of appropriateness was at 4.56 and the standard deviation was at 0.64 which means the lesson plans had the quality at a very high level. Therefore, applying the problem-based learning method teaching plan to the teaching of mathematical problem-solving ability can improve students' Mathematical problem-solving ability.

2.2 Multiple choice for Mathematical problem-solving ability

The Multiple choice consists of 30 items of multiple-choice questions, each of which has four alternatives with one correct answer. The test items consisted of four types of cognitive domains: 1) remember, 2) understand, 3) apply, and 4) analyze; The index of Item Objective Congruence (IOC) value of 30 items in the test paper was 0.80 at the lowest and 1.00 at the highest. The result of analyzing the IOC value showed that all test items were appropriate and could be used in the test. The test paper difficulty (p) was between 0.70-0.80, and item discriminability (r) should range from 0.63-0.88 and more than 0.20. The test paper reliability is 0.708 and more than 0.7 (Richardson & Kuder, 1939).

2.3 Satisfaction questionnaire

The questionnaire is provided to 5 experts for content validity check and suggestions. The quality of the questionnaire is considered according to the Index of Item Objective Congruence (IOC) obtained from the achievement test evaluation form. The IOC of each item of the satisfaction questionnaire was between 0.80-1.00. The result of analyzing the IOC index showed that 15 items in the satisfaction questionnaire were appropriate and could be used in the satisfaction evaluation of problem-based learning. The Cronbach's Alpha coefficient of the reliability of the student satisfaction questionnaire is 0.7075, which is greater than 0.70 (Cronbach, 1951). This showed that the internal consistency of the student satisfaction questionnaire met the requirements.

3. Data collection

The procedures of data collection were as follows:

3.1 The teacher provides an instructional model based on problem-based learning orientation for students before learning.

3.2 The sample was given the pretest by measuring mathematical problem-solving ability with a mathematical problem-solving ability test.

3.3 The sample was taught by using problem-based learning according to the 5 lesson plans.

3.4 After finishing the instruction, the sample received the posttest by using the same instrument that was used in the pretest.

3.5 The sample was given the students' satisfaction questionnaire.

4. Data Analysis

In this study, data were analyzed by using the statistical program according to the research objectives.

4.1 Compare mathematical problem-solving ability before and after receiving the problem-based learning method by using a t-test for dependent samples.

4.2 Compare mathematical problem-solving ability with the determined criterion set at 70 percent by using a t-test for one sample.

4.3 Assess the student's satisfaction with the problem-based learning method by using arithmetic mean and standard deviation.

Results

The results were presented according to the research objectives as follows:

1. The result of comparing the student's mathematical problem-solving ability before and after learning through using problem-based learning. The below table shows descriptive statistics and t-tests as analyzed by the statistical package program. This table aimed to answer the research objective about whether the problem-based learning teaching method was able to enhance mathematical problem-solving ability.

Table 2 Comparing the student's mathematical problem-solving ability before and after learning through using problem-based learning

Group	N	Pretest scores		Posttest scores		t	p
		M	SD	M	SD		
Experimental group	30	17.07	4.193	22.83	4.219	11.33*	.000

* $p < 0.05$

As presented in Table 2, the mean scores of the pretest of students' mathematical problem-solving ability were 17.07 ($SD = 4.193$) and the post-test of students' mathematical problem-solving ability was 22.83 ($SD = 4.219$).

On average, Post-test scores were 5.767 points higher than Pretest scores (95%). Moreover, it aimed to examine the mean score of before-and-after using Problem-based Learning to enhance mathematical problem-solving ability. The result of this table showed that after learning through Problem-based Learning in the classroom, post-test scores of students' mathematical problem-solving ability were higher than pretest scores at .05 level of statistical significance ($t = 11.330$, $p = 0.00 < .05$). The average scores of the study developed increasingly higher than pretest.

2. The result of comparing the mathematical problem-solving ability after learning through Problem-based learning with the determined criterion set at 70%. The below table shows descriptive statistics and a t-test for one sample as analyzed by a statistical package program, aimed to answer the research objective about whether problem-based learning was able to enhance mathematical problem-solving ability.

Table 3 The result that the average score of mathematical problem-solving ability after learning with Problem-based Learning is higher than the set 70%.

Group	N	Full score	Criteria score	M	SD	t	p
Experiment group	30	30	21	22.83	4.219	29.64*	0.000

* $p < 0.05$

As presented in Table 3, the mean score of the student's mathematical problem-solving ability after learning through Problem-based Learning was 22.83 from full marks of 30 and the standard deviation was 4.219. Which was statistically higher than the criterion of 70% at a .05 level of statistical significance ($t=29.644, p=0.000 < .05$).

According to the research results, we can draw the following conclusions: The average score and standard deviation of the Seventh-grader students who adopted Problem-based Learning were 22.83 points (out of 30 points) and the standard deviation was 4.219 points, which was higher than the standard of 70% at the level of statistical significance of 0.05.

It can be seen that the mathematical problem-solving ability of the students who accept Problem-based Learning is higher than 70%.

3. The result of assessing the students' satisfaction with the Problem-based Learning.

The result of comparing the mean score of Satisfaction after learning through Problem-based Learning. The below table shows descriptive statistics and t-tests as analyzed by the statistical package program. This table aimed to answer the research objective about whether using Problem-based Learning was able to enhance Satisfaction.

Table 4 Average score and satisfaction level of students' satisfaction

NO.	ITEM	<i>M</i>	<i>SD</i>	Level of appropriateness
Instructional strategy	1 Satisfied with the teaching objectives of teachers using problem-based learning	4.27	0.74	High
	2 Satisfied with the teaching content of teachers using problem-based learning	4.13	0.82	High
	3 Satisfied with the teaching methods of teachers using problem-based learning	4.33	0.66	High
	4 Satisfied with the time allocation of teachers using problem-based learning	4.07	0.78	High
Instructional resources	5 Satisfied with the teaching resources of teachers using problem-based learning	4.23	0.73	High
	6 Satisfied with the team and resource allocation during of teachers using problem-based learning	4.30	0.84	High
	7 Satisfied with the lesson plan during of teachers using problem-based learning	4.20	0.81	High
Teaching efficiency	8 Satisfied with the learning efficiency of teachers using problem-based learning	4.27	0.78	High
	9 Satisfied with the learning achievement of teachers using problem-based learning	4.13	0.78	High
	10 Satisfied with the overall status of teachers using problem-based learning	4.23	0.77	High
	11 Satisfied with the Interest of teachers using problem-based learning Interest in learning increased	4.07	0.78	High

NO.	ITEM	<i>M</i>	<i>SD</i>	Level of appropriateness
Instructional evaluation	12 Satisfied with the practical skills of teachers using problem-based learning.	4.17	0.79	High
	13 Satisfied with the problem-solving skills of teachers using problem-based learning.	4.40	0.62	High
	14 Satisfied with the self-directed learning ability of teachers using problem-based learning.	4.20	0.66	High
	15 Satisfied with the Improving academic achievements of teachers using problem-based learning.	4.27	0.64	High
	Overall Total	4.22	0.75	High

Based on the results, we can state the following: As shown in Table 4, the overall results of problem-based learning. by experts are at a very high level with ($M=4.22$, $SD = 0.75$). Thus, it was concluded that, students' satisfaction of the students after receiving problem-based learning. was high.

Discussion

1. The results of this study indicate that there are effects of problem-based learning on students' mathematical problem-solving ability. As a result, as mentioned above, the ability of students' mathematical problem-solving ability using problem-based learning is better than that before learning. This finding is in line with Astriani et al., (2017) study that studied the effect of problem-based learning on students' mathematical problem-solving ability. The results showed that the students' mathematical problem-solving ability in the experimental class increased by 36.94 after a given learning using a problem-based learning model. While the control group increased by only 27.35. It shows there is a problem-based learning model effect on students' mathematical problem-solving ability. Consistent with the research of Eviyanti et al., (2017), which found that the increase in the mathematical problem-solving ability of students who received an application of a problem-based learning model is better than students who received conventional learning material opportunities. Kurniawati et al., (2021) study that studied mathematical problem-solving ability in problem-based learning assisted by Geogebra in primary school. The final results showed that mathematical problem-solving ability from both groups of students experienced an average increase of 0.55 with a medium category.

2. The students' mathematical problem-solving ability after learning through problem-based learning was higher than the determined criterion of 70% at a .05 statistical significance level. This may be because after the knowledge content is passed on to students outside the classroom, there is a greater need for high-quality learning activities in the classroom so that students have the opportunity to apply what they have learned in a specific context. Include student creation of content, independent problem-solving, inquiry-based activities, and project-based learning. Because students discuss their opinions in groups in class and exchange different opinions with each other, they can better understand the knowledge points they have learned. This finding is in line with Prommanon & Art-in's (2022) study that studied the development of mathematical problem-solving and critical thinking abilities using problem-based learning with graphic organizers technique for grade 7 students. The results showed that the students had an average mathematical problem-solving ability of 28.69 or 71.73% of the total score, and there were 10 students or 76.92% passed the criteria which was higher than the defined criteria. The findings of this study were also consistent with studies by Sawettarapanit (2017) that the effects of problem-based learning instruction activities on Mthementicl problem-solving skills and Mthementicl connection skills of Mthyomsuks V Students. The results

showed that the mathematical problem-solving skill of Mathayomsuksa 5 students after using the problem-based learning instruction activities was higher than the set criterion of 70% at a .01 level of significance. Sochaiyan, et al., (2022) studied the development of mathematical problem-solving skills using problem-based learning with digital media on ratio, proportion, and percentage for Mathayomsuksa 1 students. The results showed that problem-based learning with digital media students had higher mathematical achievement and mathematical problem-solving skills than the regular learning activities students, at a statistically significant level of .05.

Similar to the findings in this research, Ninnuan's (2022) study studied the implementation of the learning management model based on cognitive development theory to enhance the mathematical problem-solving ability of Prathomsuksa 6 students. The results showed that the indicators of students' mathematical problem-solving abilities after learning were significantly higher than before learning at a .05 level. When considering each aspect, it was found that all of the mathematical problem-solving abilities after learning were higher than before learning at a statistical level of .05, namely, 1) finding of the problem relationship; 2) writing of mathematical diagrams; 3) problem-solving; and 4) traceability.

3. The students' satisfaction after learning through problem-based learning was at a higher level. Problem-based learning method improves students' satisfaction. The reasons may be related to the following two aspects: 1) Problem-based teaching methods can promote students' in-depth learning and cultivate students' innovative abilities. By asking inspiring questions, stimulate students' curiosity and thirst for knowledge, and guide students to study independently and actively. In the process of solving problems, students need to use their existing knowledge and skills to think and create new solutions, to improve students' ability to innovate and solve problems. 2) Problem-based teaching methods can cultivate students' comprehensive literacy and critical thinking ability. By asking challenging and diverse questions, students need to use a variety of subject knowledge and skills to analyze, synthesize, and evaluate, to develop students' comprehensive literacy in an all-round way. The findings of this study were also consistent with studies by Sochaiyan et al., (2022) the results showed that problem-based learning with digital media students had a high level of overall satisfaction. Chaphithakand & Chaipichit (2021) the findings of this study show that the student's satisfaction with the learning activities, based on Problem-Based Learning, overall, was at the "highest" level of satisfaction.

To sum up, problem-based teaching is a teaching model that takes students' problems as its starting point. It focuses on cultivating students' active learning ability, problem-solving ability, and innovation ability, stimulating students' interest and thirst for knowledge. This teaching method can promote students' deep learning, and cultivate students' comprehensive quality and critical thinking ability. It puts students at the center of their learning, gives them more autonomy and responsibility, and helps to cultivate students' all-round development qualities.

Conclusion

Through the comparative analysis of the results of the pre-test and post-test of the six-grade students using the teaching method of problem-based learning, after the intervention of problem-based learning. The conclusions were as follows:

1. The students' mathematical problem-solving ability after learning through problem-based learning than before at a statistically significant level of .05.
2. The students' mathematical problem-solving ability after learning through problem-based learning was higher than the determined criterion of 70% at a .05 statistical significance level.
3. The students' satisfaction after learning through problem-based learning was at a higher level ($M=4.22$, $SD = 0.75$).

Therefore, the problem-based learning teaching method was feasible in Primary school mathematics teaching, which helped to improve students' learning effect and mathematical problem-solving ability. The experimental results verify the research hypothesis. Moreover, students have higher satisfaction with problem-based learning. In the classroom practice of problem-based learning, the learning method their

interest in learning is stimulated, learning efficiency is improved and students are more likely to participate in learning. Students will be involved in learning faster, which helps to improve their mathematical problem-solving ability and can win the popularity of students.

In this research summary, problem-based teaching emerges as a pedagogical model that places students' real-world challenges at the forefront of instruction. It aims to cultivate students' active learning, problem-solving, and innovation capabilities, thereby fostering a keen interest in and pursuit of knowledge. This educational approach is found to facilitate profound learning experiences, nurturing students' holistic development and critical thinking skills. By prioritizing student-centered learning, problem-based teaching grants learners greater autonomy and responsibility, contributing to their comprehensive growth. Furthermore, the efficacy of Problem-Based Learning (PBL) in enhancing students' problem-solving skills is underscored by two key factors. Firstly, the methodology of problem-based teaching initiates instruction from students' inquiries, fostering their curiosity and ability to address complex problems through open-ended questioning. This approach promotes active engagement and problem-solving prowess, stimulating students' intellectual curiosity. Secondly, the student-centric nature of problem-based teaching emphasizes collaborative interaction between educators and learners. Teachers serve as facilitators, guiding students through thought-provoking inquiries and encouraging active participation in the learning process. Consequently, students assume an active role in exploring and resolving challenges, thereby refining their independent learning and critical thinking abilities.

Recommendation

Recommendation for implication

Based on the findings from the study, the following recommendations are made:

1. Identify the problem

In problem-based learning (PBL), problem identification is a crucial first step. Teachers need to choose a question that is closely related to the content of the course and at the same time arouses the interest of the students. The problem should be complex enough for students to explore in depth as they solve the problem.

2. Construct the situation

Once the problem is identified, you need to construct a situation that relates to the problem. The situation should simulate the real world as much as possible, allowing students to learn while solving real problems. The construction of scenes can be constructed through multimedia, physical objects, role-playing, and other ways.

3. Guide students to explore independently

In PBL, teachers need to guide students to conduct independent inquiry. Teachers can provide some learning resources, such as articles, videos, research reports, etc., to help students understand the problems and stimulate students' desire to explore. At the same time, teachers also need to encourage students to think independently and dare to put forward their ideas.

4. Group discussion

Group work is an important part of PBL. Students can share their ideas in small groups and find solutions to problems through discussion and communication. Group discussions can help students understand problems from different perspectives and improve their cooperation and communication skills.

Recommendation for further research

With the deepening of education reform, problem-based learning (PBL) has become an increasingly popular teaching method. To further improve the teaching effect of PBL, the following recommendations are made for future research:

1. Strengthen the problem design

Question design is the core of PBL, the future research should pay more attention to the innovation and effectiveness of question design. More challenging and realistic questions can be designed to stimulate students' desire for inquiry and increase their interest in learning. At the same time, according to the actual



situation and learning needs of students, the difficulty and content of the topic should be flexibly adjusted to ensure the pertinence and adaptability of the topic design.

2. Diversified teaching methods

With the development of educational technology, future PBL teaching should pay more attention to the application of diversified teaching methods. For example, virtual reality, augmented reality, and other technologies can be used to provide students with a more vivid and intuitive learning experience. At the same time, by introducing gamification elements and competitions, students' learning interests and participation are enhanced. In addition, teachers can creatively develop new teaching methods in combination with specific teaching content and students' characteristics.

References

- Arends, R.I. (2008). *Learning to Teach*. 6th edition. New York: McGraw-Hill.
- Astriani, N. Surya, E., & Syahputra, E. (2017). The effect of problem-based learning on students' mathematical problem-solving ability. *International journal of advance research and innovative ideas in education*, 3(2), 3440-3446.
- Barrett, T., & Moore, S. (2010). *New Approaches to Problem-Based Learning*. Routledge: London, UK.
- Chaphithakand, R. & Chaipichit, D. (2021). The Development of Grade 3 Students' Scientific Process Skill and Learning Achievement through Problem-Based Learning Activities. *Journal of Roi Kaensarn Academi*, 6(6), 215-232.
- Chimmalee, B., & Anupan, A. (2022). Effect of Model-Eliciting Activities Using Cloud Technology on the Mathematical Problem-Solving Ability of Undergraduate Students. *International Journal of Instruction*, 15(2), 981-996.
- Cronbach, L.J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16, 297-334. <https://doi.org/10.1007/BF02310555>
- David, (2011). *History of Psychology* (Guo, B. Trans.). Beijing, People's Post, and Telecommunications Publishing House.
- Demitra, & Sarjoko (2018). Effects of "Handep" Cooperative Learning Based on Indigenous Knowledge on Mathematical Problem-solving Skill. *International Journal of Instruction*, 11(2), 103-114. <https://doi.org/10.12973/iji.2018.1128a>
- Erik, T. N. (2007). *Effects of Online Problem-based Learning on Teacher's Technology Perceptions and Planning*. Retrieved from: <https://files.eric.ed.gov/fulltext/ED503759.pdf>
- Eviyanti, C.Y., Surya, E., Syahputra, E., & Simbolon, M. (2017). Improving the students' mathematical problem-solving ability by applying a problem-based learning model in VII grade at SMPN 1 Banda Aceh Indonesia. *International journal of novel research in education and learning*, 4(2), 138-144.
- Kang, M. (2020). Pay attention to thinking quality infiltration strategy teaching -- on the cultivation of Mathematical problem-solving ability of primary school students. *Teacher*, 15, 82-90.
- Kurniawati, I., Raharjo, T.J., & Khumaedi, K. (2021). Mathematical problem-solving ability on problem-based learning assisted by GeoGebra primary school. *Educational Management*, 10(1), 110-118.
- Liu, C. (2016). *Practical Operation Guide of Problem-based Learning*. BaZhong: Vocational Technical College.
- Marra, R., Jonassen, D.H., Palmer, B., & Luft, S. (2014). Why problem-based learning works: Theoretical foundations. *Journal on Excellence in College Teaching*, 25(4), 221-238.
- Ministry of Education of the People's Republic of China. (2011). *Guiding Opinions on Deepening the Reform of Primary Education and Teaching*. Beijing: Ministry of Education.
- Ministry of Education of the People's Republic of China. (2016). *Guiding Opinions on Deepening the Reform of Education and Teaching in Institutions of Higher Learning directly under the Central Government*. Beijing: Ministry of Education.
- Ministry of Education of the People's Republic of China. (2019). *Guiding Opinions on Deepening the*



- Reform of Undergraduate Education and Teaching and Comprehensively Improving the Quality of Talent Training*. Beijing: Ministry of Education.
- Ministry of Education of the People's Republic of China. (2021). *Guiding Opinions on Deepening the Reform of Primary Education and Teaching*. Beijing: Ministry of Education.
- Nie, W. (2023). *Educational theory and educational management*. Hunan Provincial Education Examination Institute.
- Ninnuan, K. (2022). Implementation of the Learning Management Model Based on Cognitive Development Theory to Enhance Mathematical Problem-Solving Ability for Prathomsuksa 6 Students. *Journal of Educational*, 8(2), 58-71.
- Noor, S.M., Muhammad, S.A., Abdul, H.A., Sharifah O., Modh H.H. & Ahmad F. (2020). Enhancing Students' Higher-Order Thinking Skills (HOTS) Through an Inductive Reasoning Strategy Using Geogebra. *International Journal of Emerging Technologies in Learning*, 15(1), 156-179.
- Prommanon, N. & Art-in, S. (2022). The development of mathematical problem-solving and critical thinking abilities using problem-based learning with graphic organizers technique for grade 7 students. *Journal of Roi Et Rajabhat University*, 16(3), 51-63.
- Rahman, A., & Ahmar, A.S. (2016). Exploration of Mathematics Problem-solving Process Based on The Thinking Level of Students in Junior High School. *International Journal of Environmental & Science Education*, 11(14), 7278-7285.
- Richardson, M.W., & Kuder, G.F. (1939). The calculation of test reliability coefficients is based on the method of rational equivalence. *Journal of Educational Psychology*, 30(9), 681-687.
<https://doi.org/10.1037/h0054933>
- Rudibyni, R.B., Perdana, R., & Elisanti, E. (2020). Development of Problem-Solving- Based Knowledge Assessment Instrument in Electrochemistry. *International Journal of Instruction*, 13(4), 957-974.
- Sawettarapanit, I. (2017). The effects of problem-based learning instruction activities on Mathematical problem-solving skills and Mathematical connection skills of Mathayomsuksa V students. Master's thesis, Burapha University: DSpace at Burapha University.
<https://buuir.buu.ac.th/xmlui/handle/1234567890/7119>
- Simanjuntak, M. P., Hutahaean, J., Marpaung, N., & Ramadhani, D. (2021). Effectiveness of Problem-Based Learning Combined with Computer Simulation on Students' Problem-Solving and Creative Thinking Skills. *International Journal of Instruction*, 14(3), 519-534.https://www.e-iji.net/dosyalar/iji_2021_3_30.pdf
- Sochaiyan, C., Phattarachaleekul, M., & Chutiman, N. (2022). Development of mathematical problem-solving skills using problem-based learning with digital media on ratio, proportion, and percentage for Mathayomsuksa 1 students. *Journal of Education Rajabhat Maha Sarakham University*, 18(3), 201-214.
- Sudarman, S. (2007). Problem-based Learning: A Learning Model for Developing and Improving Problem-solving Skills. *Journal Pendidikan Inovatif*, 2, (2), 68-73.
- Wei, T. (2020). Analysis of the cultivation strategy of Mathematical problem-solving ability of primary school students. *Love Science Every Day (Frontiers in Education)*, 3, 1-10.
- Zong, B. (2020). Cultivation of Mathematical problem-solving ability of primary school students. *The Big World of Mathematics (Middle)*, 5, 49-56.
- Zulkarnain, Z., Zulnaidi, H., Heleni, S. and Syafri, M. (2021). Effects of SSCS Teaching Model on Students' Mathematical Problem-solving Ability and Self-efficacy. *International Journal of Instruction*, 14(1), 475-488. <https://doi.org/10.29333/IJI.2021.14128A>