EFFECTS OF THE PROBLEM-BASED LEARNING ON THE MATHEMATICS PROBLEM-SOLVING ABILITY OF THE FOURTH-GRADE PRIMARY SCHOOL STUDENTS OF SUNSHINE PRIMARY SCHOOL IN ZHONGYUAN DISTRICT, ZHENGZHOU CITY, HENAN PROVINCE

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ABSTRACT

The objectives of this study were to: 1) compare students' mathematics problem-solving ability before and after learning through problem-based learning, 2) compare students' mathematics problem-solving ability after learning through PBL with the determined criterion set at 70%. and 3) assess students' satisfaction after learning problem-based learning. The sample of this study was 30 students in Grade 4(1classroom) from Sunshine Primary School, Zhongyuan District, Zhengzhou City, Henan Province, which was derived by using cluster random sampling method. The research instruments were as follows: 1) the appropriateness of the lesson plans were based on PBL at very high level (M=4.60, SD= 0.54), 2) mathematics problem-solving ability test with a difficulty (p=0.40-0.77) and discrimination (r=0.20-0.40) with a reliability of .71, and 3) a student satisfaction questionnaire with a reliability of 0.73. The statistics used to analyze data were mean, standard deviation, t-test for dependent samples and t-test for one sample.

The results of this study were as follows:1) after using problem-based learning teaching method for the fourth grade, students' mathematics problem-solving ability (*M*=22.07, SD=1.38)are higher than before (*M*=15.4, *SD*= 1.59) with a statistically significant .01 level(t_{29}=25.25, *p*= .00 1),2) students' mathematics problem-solving ability was higher than the 70% at a significance level of .01 (*M*=22.07, *SD*= 1.38 ,t_{29}=4.37, *P*=.00 1) . 3) the students' satisfaction after learning through problem-based learning teaching method was at (*M*=4.02, *SD*=0.72).

Keywords

Problem-based Learning, mathematics problem-solving ability, students' satisfaction

Significance of the problems

Today's society is an era of knowledge explosion, and the requirements of the society for talents are getting higher and higher. The thinking and creative ability, language ability and social communication ability cultivated by traditional education are still essential. In order to succeed in today's world of innovation and change, it is very important to have new capabilities such as definition and solve problems. (Gu Mingyuan, 2016). However, teaching and learning in elementary education still largely focus on traditional knowledge transmission, which may not effectively meet the demands for essential 21st-century skills (Hmelo-Silver, 2004; Savery, 2006). Moreover, scholars have observed that many students lack deep analytical and problem-solving abilities, which are critical for effective learning and life skills (Jonassen, 2011).

Problem-based Learning (PBL) teaching method is characterized by let the students involve in the real problem situation of learning teaching methods, in higher vocational teaching is actually "task driven" or "project driven", through such learning, students can put the theoretical study in school and real life problems, enhance the purpose and practicability of learning. It is "based on the problem" is generally derived from real life, close to the society, close to the students 'future jobs, close to the students' real ideas, make students obviously feel today's learning is for tomorrow's employment, is to adapt to the needs of the rapid take-off of society, It is far more than students in the classroom and books facing the world image, much more vivid, much broader, much more profound, and much more practical. PBL teaching method emphasizes the ability to solve practical problems, and emphasizes the close combination of theory and practice. In the teaching process, students can solve practical problems by searching information and collecting information, so as to master skills to acquire corresponding scientific knowledge, so that they can "know how" and then "know why" (Lian, 2013). According to Barrows and Tamblyn (1980), PBL effectively promotes analytical thinking and problem-solving skills, and numerous studies have demonstrated that it significantly improves students' academic achievement, especially in mathematics (Savery, 2006; Strobel & van Barneveld, 2009). Furthermore, PBL fosters positive attitudes toward learning and enhances students' responsibility for their own learning (Lubis et al., 2023; Yulianti et al., 2021; Hasanah & Asra, 2022).

Nevertheless, although PBL has been widely recognized for linking theory to real-world problems, there remains a lack of research specifically exploring how PBL develops critical 21st-century competencies such as problem definition, adaptive thinking, and meaningful learning motivation. Additionally, the transition from "knowing how" to "knowing why" within PBL has not been systematically examined. This study aims to fill these gaps by investigating the effects of PBL on the learning achievement and mathematical problem-solving ability of fourth-grade students in Sunshine primary school, focusing on the mathematics course to develop students' mathematics problem-solving ability.

Research questions/ Research problems (in case of being provided)

1. How is the mathematics problem-solving ability improved through problem-based learning (PBL) before and after learning?

2. How is the mathematics problem-solving ability of students after learning through problem-based learning (PBL) comparing with the determined criterion of 70%?

3. How is the student' s satisfaction toward problem-based learning (PBL) after learning through problem-based learning (PBL)?

Research objectives

1. To compare students' mathematics problem-solving ability before and after learning through problem-based learning.

2. To compare students' mathematics problem-solving ability after learning through PBL with the determined criterion set at 70%.

3. To assess students' satisfaction after learning problem-based learning.

Research findings

This study employed a one-group pretest-posttest experimental design to examine the effects of Problem-Based Learning (PBL) on students' mathematical problem-solving ability. The objectives of the study were threefold:

1) to compare students' mathematics problem-solving ability before and after learning through problem-based learning,

2) to compare students' mathematics problem-solving ability after learning through PBL with the determined criterion set at 70%. and

3) to assess students' satisfaction after learning problem-based learning.

The sample consisted of 30 Grade 4 students selected using cluster random sampling from among four Grade 4 classrooms at Sunshine Primary School, Zhongyuan District, Zhengzhou City, Henan Province.

The research instruments were as follows:

1) the lesson plans were evaluated by 5 experts using a five-point scale, yielding an average score of 4.60 (SD = 0.54), indicating a very high level of appropriateness.

2) the mathematics problem-solving ability test consisted of 30 items. The content validity was confirmed by five experts. The Item-Objective Congruence (IOC) values for all items were above 0.50, ranging from 0.60 to 1.00. The test had item difficulty indices ranging from 0.40 to 0.77, and discrimination indices ranging from 0.20 to 0.40. The reliability of the test, as calculated by the Kuder-Richardson Formula 20 (KR-20), was 0.71.

3) a student satisfaction questionnaire was developed, and its reliability, as measured by Cronbach's alpha coefficient, was 0.73.

Data were analyzed using both descriptive and inferential statistics. The mean and standard deviation were used to describe students' mathematics problem-solving scores. A dependent-samples t-test was conducted to compare students' ability before and after the implementation of problem-based learning. A one-sample t-test was employed to examine

whether students' post-test scores met the predetermined criterion of 70%. Student satisfaction was analyzed using descriptive statistics.

The study results are as follows:

1) The result of comparing students' mathematics problem-solving ability before and after learning through problem-based learning , as shown below.

Table 1 Comparison results of different students' mathematics problem-solving ability before and after learning through problem-based learning

Group	N	Pre-test scores		Post-test scores		*t*	*p*
		M	*S.D*	*M*	*S.D*		
experimental group	30	15.4	1.59	22.07	1.38	25.25**	.001

**p＜0.01

As presented in Table1, the mean scores of pretest of students' mathematics problem-solving ability was 15.4 (*SD*=1.59) and posttest of students' mathematics problem-solving ability was 22.07, (*SD*=1.38).

Moreover, it aimed to examine the mean score of before-and-after using PBL method to enhance mathematics problem-solving ability. The result of this table showed that after learning through PBL method in the classroom, posttest scores of students' mathematics problem-solving ability was higher than pretest scores at .05 level of statistical significance (t_{29} = 25.25, p < .01). The average scores of the study developed increasingly higher than pretest.

2.The result of comparing students' mathematics problem-solving ability after learning through PBL with the determined criterion set at 70%.

Table 2 The result of comparing the students' mathematics problem-solving ability after learning through PBL with the determined criterion set at 70%.

Group	N	Full score	Criteria score	*M*	*SD*	*t*	*p*
Experimental group	30	30	21	22.07	1.38	4.37**	0.001

**p＜0.01

As presented in Table 2, the students' mathematics problem-solving ability after learning through PBL (*M*=22.0 and *SD*=1.38) was higher than the criterion set at 70 percent. (Criteria score = 21) with the statistical significance of .05 level (t_{29} =4.37, p < .001).

3. The results of assessing students' satisfaction after learning problem-based learning. The below table showed descriptive statistics .This table aimed to answer the research objective about whether using PBL method was able to enhance students' satisfaction.

Table 3 The results of students' satisfaction after learning through PBL method

NO.	ITEM	*M*	*SD*	Level of Satisfaction
1	**Learning aspect**			
	1.1 Interactions in class include changing the communication between students or teachers and students	3.77	0.73	High
	1.2 PBL classroom self-study link, you can take the initiative to complete the tasks assigned by the teacher	3.93	0.74	High
	1.3 In PBL classroom, you can participate in group discussions	4.10	0.71	High
	Total	3.93	0.73	High
2	**Instructional strategy**			
	2.1 You finished the pre-class study task list on time	3.97	0.89	High
	2.2You interact and communicate in the classroom to improve your ability to explore and learn independently	3.93	0.78	High
	2.3 You study in the classroom with the group to stimulate enthusiasm and participation	4.10	0.84	High
	2.4 Teachers provide personalized guidance to students	4.00	0.79	High
	2.5 Teacher collective guidance strategies	3.93	0.83	High
	Total	3.99	0.83	High
3	**Teaching media aspect**			
	3.1 Compared with the traditional classroom, I like the teaching method of PBL classroom	4.10	0.80	High
	3.2 You believe that you have mastered the content of the course activities provided to you	3.97	0.67	High

NO.	ITEM	*M*	*SD*	Level of Satisfaction
	3.3 With the PBL classroom teaching, you can actively answer the teacher's questions	4.07	0.74	High
	Total	4.05	0.74	High
4	Assessment aspect			
	4.1 The degree to which you think you have completed problem-based learning tasks	4.10	0.76	High
	4.2 In PBL course teaching, you can feel a deeper understanding of knowledge points through teachers' understanding of pre-class problem solving, systematic teaching of knowledge and discussion of problems between students	4.23	0.77	High
	4.3 You think that using the PBL classroom teaching will improve your grades	3.97	0.85	High
	4.4 You feel that PBL classroom will deepen your understanding of what you learn	4.13	0.78	High
	Total	4.10	0.79	High
Overall		**4.02**	**0.72**	**High**

As shown in table 3, the overall the results of students' satisfaction after learning through PBL method was at high level (*M*=4.02, *SD* = 0.72), and the results with each aspects were shown as follows:

Learning aspect by the total 1 results were at high level with (*M*= 3.93, *SD* = 0.73), and each item were followed this: Interactions in the classroom include changes in communication between classmates or teachers and students at very high level (*M*=3.77 *SD.*=0.73), PBL self-study link, you can take the initiative to complete the tasks assigned by the teacher were at very high level with (*M*=3.93 *SD*=0.74) and In PBL teaching, you can participate in the group discussions were at very high level with (*M*=4.10 *SD.*=0.71).

Instructional strategy by the results were at high level with (*M*= 3.99, *SD* = 0.83), and each item were followed this: You completed the pre-class study task list on time at very high level (*M*=3.97 *SD*=0.89), You interact and communicate in class to enhance your ability of independent exploration and learning were at very high level with (*M*=3.93 *SD*=0.78),You work with groups to learn in class to arouse enthusiasm and participation were at very high level with

(*M*=4.10 *SD*=0.84), Teachers give personalized guidance to students were at very high level with (*M*=4.00 *SD*=0.79) and Teachers' collective guidance strategy for existing problems were at very high level with (*M*=3.93 *SD*=0.83).

Teaching media aspect by the results were high level with (*M*= 4.05, *SD* = 0.74), and each item were followed this: Compared with the traditional classroom, I like PBL teaching method at very high level (*M*=4.10 *SD*=0.80), You believe that you have mastered the content of the course activities provided to you by the teacher were at very high level with (*M*=3.97 *SD*=0.67), and With PBL teaching, you can actively answer the teacher's questions were at very high level with (*M*=4.07 *SD*=0.74*).*

Assessment aspect by the results were at high level with (*M*= 4.10, *SD* = 0.79), and each item were followed this: The degree to which you think you have completed the learning task of the pre-class video at very high level (*M*=4.10 *SD*=0.76), In the flipped class, you can feel a deeper understanding of the knowledge points through the teacher's solution of the pre-class problems, the systematic teaching of the knowledge, and the discussion of the problems between the students were at very high level with (*M*=4.23 *SD*=0.77), You think using PBL teaching will improve your grades were at very high level with (*M*=3.97 *SD*=0.85), and You feel that PBL teaching will deepen your understanding of what you are learning were at very high level with (*M*=4.13 *SD*=0.87).

Discussion

Objective 1: To compare students' mathematics problem-solving ability before and after learning through problem-based learning.

The findings revealed that students' mathematics problem-solving ability significantly improved after participating in the problem-based learning (PBL) activities. This improvement reflects the strength of the PBL approach in fostering independent thinking, active engagement, and critical analysis. As Lian (2013) asserted, PBL encourages students to explore real-life problems, formulate hypotheses, search for relevant information, and derive logical conclusions through reflective thinking. The nature of this student-centered learning process enables learners to construct knowledge through authentic experiences, thereby enhancing deeper understanding and self-directed learning.

This result is in agreement with Inchan (2022), who found that students demonstrated significantly higher academic achievement after receiving instruction through PBL. These findings affirm that PBL not only increases cognitive engagement but also promotes problem-solving skills that are essential in mathematics and other disciplines.

Objective 2: To compare students' mathematics problem-solving ability after learning through PBL with the determined criterion set at 70%.

The study also found that the students' average scores exceeded the 70% performance benchmark, indicating that the implementation of PBL effectively meets the intended learning outcomes. This aligns with the findings of Chanfun (2019), who reported that students attained an average score of 87.49% in mathematics problem-solving tasks after engaging in PBL-based instruction, significantly higher than the set criterion.The high performance can be attributed to the motivational impact of PBL, which emphasizes learner autonomy, critical thinking, and collaborative problem-solving. According to Sun (2014), PBL transforms

traditional didactic instruction into an interactive process where students are encouraged to co-construct knowledge with teachers and peers. Through guided inquiry and group discussions, students deepen their understanding and develop meta-cognitive strategies that enhance academic achievement. Moreover, PBL facilitates the integration of knowledge into practical contexts, bridging classroom learning with real-world applications.Consistent with this, Yulianti, Suryani, and Fitriana (2021) conducted a study on junior high school students and found that students taught using PBL achieved significantly higher scores in mathematical reasoning and problem-solving ability compared to those taught by traditional methods. Similarly, Lubis, Simarmata, and Rahman (2023) found that PBL significantly improved students' learning outcomes in mathematics and fostered more active participation and confidence in solving real-world problems.

Objective 3: To assess students' satisfaction after learning through problem-based learning.

The results also indicated that students reported a high level of satisfaction with their learning experiences during the PBL process. Students expressed that PBL increased their interest in mathematics, improved their ability to learn independently, and enhanced their classroom participation. This finding supports Mierson and Parikh (2000), who emphasized that real-world, problem-centered learning environments make learning more meaningful and intrinsically motivating. Additionally, as noted by Mongkut and Seehamongkon (2023), students engaged in PBL reported high satisfaction levels (M = 4.44), highlighting the benefits of peer collaboration, student-teacher interaction, and group reflection. In this study, students were encouraged to prepare before class, engage in group work, actively participate in discussions, and reflect on their learning. These experiences not only fostered academic growth but also cultivated teamwork, communication, and emotional intelligence—skills essential for lifelong learning in the 21st century. Furthermore, the findings are consistent with those of Sereenonchai and Rattanatumma (2020), who found that Thai undergraduate students showed significantly higher satisfaction when learning via PBL, especially in areas of engagement and perceived relevance of content. Similarly, a study by Hasanah and Asra (2022) concluded that secondary students learning mathematics through PBL reported increased enjoyment and motivation due to the active and collaborative nature of the approach.

Recommendation

1.1 Meaning of the recommendations

During the three learning phases of PBL, pre-class learning in PBL differs from traditional classroom learning. Students need to be clearly aware that they need to be responsible for their own learning outcomes through pre-class self-learning, rather than thinking that pre-class learning is just a preparation or preview of classroom activities.

1) Teachers need to strengthen the knowledge reserve of PBL method, strengthen theoretical learning, improve teaching ability, and conscientiously complete course preparation carefully, so that teachers can have confidence in teaching.

2) In the teaching, the PBL method takes students as the main body, takes teachers as the leading body, and completes the teaching organization. Although the teacher is

the guide, but the teacher can not let the students go, because the teacher guides the students to learn actively, so the students become the main body of learning.

3) In the practice of PBL method, teachers should guide students to actively learn the content of this course, and always maintain supervision and guidance, so that students will not deviate from the theme in the learning process.

4) The PBL method can effectively improve students' academic performance in the actual classroom teaching process. Therefore, if conditions permit, the PBL methods should be prioritized in the classroom.

Before class, the video synchronization course plan and micro-video should be optimized, and the design should be inspirational and interesting. Because students should use interesting materials, the video should pay attention to the following aspects: first, select and produce excellent teaching video is the necessary ability for teachers; second, the micro video must be concise, vivid voice, humorous language, and better to cooperate with other teachers to attract the attention of students; third, the video content should be gradual, from shallow to deep, the overall structure is complete, conducive to students 'systematic learning; fourth, the question should be appropriate, enlightening to guide students to think, the general setting of the problem should start from the students' existing experience from shallow to deep.

In the classroom, the three treasures (teaching plans, courseware, teachers) are essential and should be combined with inquiry activities and knowledge teaching. The success or failure of achieving the course goal mainly lies in the classroom teaching. The brightest part of the new model is that students watch videos before class. On the other hand, in the "new teaching", after students' initial contact with knowledge points, teachers correctly integrate the problems that students feedback to teachers before class, and solve problems for students through continuous communication and explanation in the student group, so as to achieve the purpose of better teaching. Moreover, this teaching model combines the advantages of traditional teaching and medical teaching, while focusing on knowledge teaching and students' independent learning. Teaching is completed in the positive interaction between teachers and students, so that students can master the systematic and complete knowledge in the process of learning activities. On the basis of ensuring the logic and content integrity of students 'learning knowledge, students' thinking is more optimized.

After class, we should respect the students' differences and encourage the students to think. The PBL teaching model provides teachers with more opportunities to observe and understand the student state of mind in the classroom, and to discover the individual uniqueness among the students. The new era has new requirements for education, which requires the current talents to be independent learners, independent thinkers, able to solve problems independently and have creative thinking. Therefore, the task of teachers is to help students constantly think and reflect, and strive to meet these standards. In the traditional classroom teaching process, the PBL teaching method can effectively improve the students' academic performance. Therefore, if conditions permit, the teaching method of PBL should be given priority in the classroom.

1.2 Further research is recommended

(1) Due to the limited time and energy of the research, the selection range of subjects is narrow. In order to make the scientific research, different classes, school types, regional differences and other factors will be taken into account in the future research may have a certain impact on the research results.

(2) PBL teaching mode requires higher teachers' comprehensive teaching ability than the traditional mode. In the implementation of this mode of teaching, teachers cannot really meet the requirements of PBL teaching. Secondly, this model is not a prescriptive model, which requires teachers to flexibly use this model in the teaching process according to the specific situation of individual students and the whole class.

(3) Due to many objective reasons, such as my limited reading literature, my research level and writing ability need to be improved, the research needs to be more thorough and careful, which will improve the level of scientific research in the future study and work and make better teaching research.

Although PBL teaching method has been widely used in medical vocational education and higher education field, its practice in the field of primary education is still quite poor, decentralized and unsystematic. PBL education is oriented to the future, and the more important long-term goal should be to cultivate students' sense of responsibility and initiative to actively manage themselves from an early age. From previous studies, it is not difficult to find that the transformation of students from a traditional teaching education to a new teaching mode needs a process. In this process, they need to make both psychological and behavioral adjustment and transformation, which may cause a series of problems. The reasonable way to solve this problem is to have the students in their learning career

In the early stage, they can immerse themselves in the appropriate PBL teaching environment, so that the PBL teaching method will become a part of their learning experience and lay a solid foundation for adapting to their future life. PBL, of course, teaching method applied to the beginning of primary education in our country, there are still problems to be solved, but at the same time we should see a line of teachers are learning from the advanced experience at home and abroad, to through the teaching mode and teaching environment constantly enrich and perfect, let the PBL teaching method better into the primary school teaching practice, play a bigger role.

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