

Activity-Based Learning and Higher-Order Questions for Developing Mathematics Problem-Solving Ability in Sixth-Grade Students

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Received: April 4, 2025

Revised: April 24, 2025

Accepted: April 29, 2025

Abstract: The purpose of this research was to: 1) Compare the mathematics learning outcomes of Grade 6 students before and after the implementation of a learning process based on activities combined with higher-order questioning. 2) Compare the problem-solving abilities of Grade 6 students in mathematics before and after the implementation of a learning process based on activities combined with higher-order questioning. And 3) Investigate the satisfaction of Grade 6 students towards the learning process based on activities combined with higher-order questioning. The sample group used in this study consisted of 14 Grade 6 students from Wat Sukkasem School, Semester 1, Academic Year 2024. The sampling method using cluster random sampling using school as the unit for sampling. The research instruments included: 1) A lesson plan based on activities combined with higher-order questioning. The Index of Item Objective Congruence (IOC) from the 5 experts ranged from 0.80 to 1.00. 2) A test to measure learning outcomes. The difficulty index (p) of the final version ranged from 0.30 to 0.80, and the discrimination power (r) ranged from 0.2 to 0.6. The test's reliability, calculated using the Kuder-Richardson formula (KR-20), was found to be 0.84, which is within an acceptable range. 3) A test to assess problem-solving abilities in mathematics. The analysis revealed that the difficulty values ranged from 0.65 to 0.67, the discrimination power values ranged from 0.22 to 0.30, and the Cronbach's alpha coefficient was 0.98, which met the acceptable criteria. and 4) A satisfaction survey. The analysis revealed that the IOC values were 1.00 for all evaluation items. The statistical methods used to analyze the data included the mean (M), standard deviation (SD), and t-test for dependent samples. The results of the research showed that: 1) The learning outcomes in mathematics were significantly higher than before the lesson, with statistical significance at the .05 level. 2) The problem-solving abilities were significantly higher than before the lesson, with statistical significance at the .05 level. 3) The overall satisfaction level was very high.

Keywords: Activity-based learning, High-level questioning, Mathematical problem-solving

Introduction

Mathematical problem-solving is crucial and should be developed within students. As stated by the National Council of Teachers of Mathematics (NCTM) in the United States, problem-solving should be a central focus of mathematics education. This has led educators worldwide to pay attention to studying mathematical problem-solving at all levels of the curriculum (The Institute for the Promotion of Teaching Science and Technology, 2012). Additionally, the National Education Act of 1999 emphasizes the importance of the learning process and states in Section 4, Clause 24 that schools and related agencies should provide opportunities for students to practice thinking skills, management, facing situations, and applying knowledge to prevent and solve problems. Schools should also organize activities that allow students to learn from real experiences, practice doing things, think critically, and develop a continuous love for reading and learning (Office of the Basic Education Commission, 2019).

In the 2008 Basic Education Core Curriculum (2017 revised edition), the Mathematics Learning Area was designed with a focus on equipping students with the necessary skills for 21st-century learning. These include critical thinking, problem-solving, creative thinking, technology use, communication, and collaboration. This aims to prepare students to understand the changing systems of the economy, society, culture, and environment, enabling them to compete and coexist in the global community. A successful mathematics

learning process must prepare students to be ready to learn new things. Therefore, the Mathematics Learning Area defines mathematical skills and processes as abilities to apply knowledge in learning various subjects to gain new knowledge and use it effectively in daily life.

The mathematical skills and processes emphasized here are the skills and processes necessary and should be developed in students. Problem-solving, one of the five essential skills and processes of mathematics, involves the ability to understand a problem, think critically, plan a solution, and select appropriate methods while considering the reasonableness of the answer and checking its correctness. This is a process that students should learn, practice, and develop to build confidence in solving problems both inside and outside the classroom. Moreover, this is a fundamental skill that students can carry with them to solve real-life problems. Critical thinking and problem-solving ability are a key concept in teaching students to think, do, and solve problems, as reflected in the objectives of various education programs from basic education to higher education.

From the principles and reasoning above, it is evident that the problem-solving process in mathematics is an essential skill for developing students' mathematical abilities. However, in the present day, the teaching methods to develop problem-solving skills in mathematics are integrated into all subject areas but have not been as successful as expected. This is reflected in the results of the Basic Education National Test (O-NET) for Grade 6 students from the 2017 to 2023 academic years, where the average scores for mathematics at the national level were 37.12%, 37.50%, 32.90%, 29.99%, 36.83%, 28.06%, and 29.96% respectively. The average scores in regional educational areas were 40.17%, 42.93%, 36.22%, 30.98%, 37.95%, 30.14%, and 32.52%. The average scores at the group of schools' level were 38.53%, 41.79%, 37.70%, 32.87%, 39.10%, 30.95%, and 33.61%. When comparing the average scores of Wat Sukkasem School, which were 41.33%, 41.88%, 37.00%, 38.57%, 52.73%, 30.84%, and 35.67%, it was found that the averages at all levels were below 50%, which is considered unsatisfactory and lower than other subjects. This has affected the quality of students and the overall education system, and the results should be analyzed to improve further.

The situation reveals that students need development both in knowledge and problem-solving skills in mathematics. Mathematics teachers must find teaching methods that promote students' ability to think critically and solve problems in mathematical situations. This will help students think critically, act competently, solve problems effectively, and live harmoniously with others. Learning aimed at developing problem-solving skills will help students understand problems, identify causes, and foresee the consequences. The Institute for the Promotion of Teaching Science and Technology (2012) states that problem-solving is a process that learners should learn, practice, and develop as a skill to create new knowledge, think diversely, adapt problem-solving methods appropriately, and have confidence in solving problems both inside and outside the classroom. Moreover, problem-solving is a basic skill that learners can apply in real life. To promote effective learning in problem-solving, mathematical problems that stimulate interest and promote the application of mathematical knowledge, problem-solving processes, and various problem-solving strategies should be used.

Teachers should adjust the learning style from passive Learning to active learning. For organizing activity-based learning, it is a student-centered learning approach where students are actively involved in each learning activity. In each session, students engage in various activities designed by the teacher effectively to promote learning, understanding, and skills through real practice. The teacher serves as a facilitator and motivates students to discover

knowledge by themselves while creating a fun and engaging learning environment. Group activities encourage students to think and express themselves appropriately. The process can be summarized into five steps: 1) Stimulate and review prior experience 2) Organize activities 3) Exchange and reflect on learning 4) Summarize and apply the knowledge 5) Evaluate the process.

One technique that can support activity-based learning is the use of higher-order questioning. Higher-order questions help stimulate students to engage in deep thinking, critical analysis, and problem-solving. According to Bloom's Revised Taxonomy (Anderson & Krathwohl (2001) these questions can be categorized as follows: 1) Analysis questions: These questions help students organize and classify related data. 2) Evaluation questions: These questions encourage students to critique work and evaluate the appropriateness of processes or outcomes in problem-solving. 3) Creating questions: These questions require students to generate new hypotheses, create new procedures, or develop innovative ideas to solve problems.

Based on the significance and information above, the researcher is interested in applying activity-based learning combined with higher-order questioning in teaching mathematics to improve the learning outcomes and problem-solving abilities of Grade 6 students, and to enhance the quality and effectiveness of mathematics instruction. The objective is 1) Compare the mathematics learning outcomes of Grade 6 students before and after the implementation of a learning process based on activities combined with higher-order questioning. 2) Compare the problem-solving abilities of Grade 6 students in mathematics before and after the implementation of a learning process based on activities combined with higher-order questioning. And 3) Investigate the satisfaction of Grade 6 students towards the learning process based on activities combined with higher-order questioning.

Research methodology

This research is an experimental study using a Pre-Experimental Research design, specifically the One-Group Pretest-Posttest Design. The population used in this study consists of Grade 6 students in the first semester of the 2024 academic year from the Sukphannikar Group in the Suphanburi Primary Education Service Area Office 1, covering a total of 14 schools, with 1 classroom per school, totaling 14 classrooms and 125 students. The sample group consisted of 14 Grade 6 students from Wat Sukkasem School, located in Bang Plama District, Suphanburi Province. The sample was selected using cluster sampling, with the school being the unit of selection. The research experiment utilized four research instruments, which are:

1. The lesson plan using activity-based learning combined with higher-level questioning on the topic of Ratios and Percentages for Grade 6 students consists of 5 plans, totaling 18 hours. The researcher studied and analyzed the 2017 Revised Basic Education Core Curriculum (B.E. 2551) and the curriculum of Wat Sukkasem School, as well as books and research related to the development of mathematical problem-solving abilities, to create the lesson plan. The plan was then presented to the thesis advisor for accuracy verification, followed by submission to 5 experts for evaluation, which included: 1) Two experts in mathematical content, 2) Two experts in curriculum and mathematics teaching, and 3) One expert in measurement and evaluation. The purpose of this was to examine the content validity, the accuracy of the language used, and the appropriateness of the teaching activities.

The Index of Item Objective Congruence (IOC) from the 5 experts ranged from 0.80 to 1.00, indicating that the plan was appropriate and usable. The lesson plan was then tested on a non-sample group, consisting of 20 Grade 6 students from Wat Talum School, Suphanburi Province, in the first semester of the 2024 academic year. One plan was tested over 4 hours from September 10–13, 2024, to assess its feasibility for real-life application. The trial run showed that the time allocated for each step of the learning activity was longer than expected. Adjustments were made by streamlining the steps of the activities to make them more concise. These improvements made the learning activities more suitable for the content and the execution of the tasks, which led to a more effective development of students' abilities and learning processes.

2. The Learning Achievement Test on the Topic of Percentages and Ratios
The researcher studied the theory, principles, and methods of constructing achievement tests from curriculum documents and related research. The researcher also analyzed the indicators that align with the content on Percentages and Ratios to create a multiple-choice test consisting of 30 items, which was then refined to 20 items to be used as the final version of the test. The test was presented to the thesis advisor for accuracy verification, followed by submission to 5 experts who reviewed the accuracy of the measurements and used their judgment to verify the content validity. The Index of Item Objective Congruence (IOC) values were calculated based on the expert analysis. The results showed values between 0.80 and 1.00. Following the expert feedback, the test was revised to correct any inappropriate questions and answer choices, as well as unclear images. The revised test was then trialed with Grade 6 students who had already studied Percentages and Ratios but were not part of the sample group. These students were from Wat Dao School, Bang Pla Ma District, Suphanburi Province, with a total of 20 students in the first semester of the 2024 academic year. After selecting 20 items that met the criteria, the difficulty index (p) of the final version ranged from 0.30 to 0.80, and the discrimination power (r) ranged from 0.20 to 0.60. The test's reliability, calculated using the Kuder-Richardson formula (KR-20), was found to be 0.84, which is within an acceptable range. Therefore, the achievement test on Percentages and Ratios was then used with the sample group, consisting of 14 Grade 6 students from Wat Sukkasem School, Bang Pla Ma District, Suphanburi Province, in the first semester of the 2024 academic year.

3. Mathematical Problem-Solving Ability Test. The researcher studied the method of constructing subjective tests from related documents and research to create a mathematical problem-solving ability test. The test was designed as a subjective test by creating 10 problem scenarios, from which 5 questions were selected to be used as the research tool. Each question was assigned a full score of 12 points. The test was then presented to the thesis advisor for review, and subsequently to 5 experts to verify the quality, content validity, language usage, and measurement and assessment aspects. The Index of Objective Congruence (IOC) was calculated. The analysis of the IOC values showed a score of 1.00 for all items. The mathematical problem-solving ability test was then trialed with students who were not part of the sample group and had already learned the content. The scoring was done according to the specified criteria, using a 3-level scoring rubric. The rubric included four evaluation criteria: 1) Understanding the problem, 2) Planning the solution, 3) Implementing the solution, and 4) Reviewing the solution. After selection, the researcher calculated the internal consistency reliability using Cronbach's alpha coefficient. The analysis revealed that the difficulty values ranged from 0.65 to 0.67, the discrimination power values ranged from 0.22 to 0.30, and the Cronbach's alpha coefficient was 0.98, which met the acceptable criteria. The mathematical problem-solving ability test was then trialed

with the sample group of Grade 6 students at Wat Sukkasem School, Bang Pla Ma District, Suphanburi Province, totaling 14 students, in the first semester of the 2024 academic year.

4. Student Satisfaction Questionnaire. The researcher studied the format and methods of creating a student satisfaction questionnaire regarding the learning process using activity-based learning combined with higher-order questioning. The questionnaire was divided into two sections: Section 1: A questionnaire about satisfaction with teaching the topics of percentages and ratios, which consists of 5 aspects: 1) The organization of learning activities 2) Learning materials 3) Assessment and evaluation 4) The benefits gained from the learning There were 5 items for each aspect, totaling 20 items. This section used a Rating Scale with 5 levels: Very High, High, Medium, Low, and Very Low. Section 2: An open-ended questionnaire about the students' opinions on the learning process and suggestions for improvement, with 1 question.

The researcher submitted the student satisfaction questionnaire to the thesis advisor for review, and the questionnaire was then presented to 5 experts for content validity checks. The feedback from the experts was used to calculate the Index of Item Objective Congruence (IOC). Items with an IOC value greater than 0.50 were selected. The analysis revealed that the IOC values were 1.00 for all evaluation items, indicating that the satisfaction questionnaire was valid. The student satisfaction questionnaire was then used as a research tool with the sample group: Grade 6 students at Wat Sukkasem School, Bang Pla Ma District, Suphanburi Province, totaling 14 students, in the first semester of the 2024 academic year.

In conducting the experiment, the researcher carried out the experiment and collected data in the 2024 academic year, totaling 22 hours. The experiment was divided into 3 phases as follows:

1. Pre-experiment phase: This phase involved the researcher preparing various aspects as follows:

1.1 Developing research tools, which included: 1) A lesson plan for the mathematics subject on ratios and percentages for Grade 6 students, using activity-based learning combined with higher-order questioning. 2) A learning achievement test on ratios and percentages. 3) A mathematical problem-solving ability test. 4) A student satisfaction questionnaire on activity-based learning combined with higher-order questioning.

1.2 The researcher reviewed the teaching methods for the target student group.

1.3 Students were asked to take the pretest on ratios and percentages, which was the same test as the post-test, lasting 1 hour.

1.4 Students were asked to take the pretest on mathematical problem-solving ability related to ratios and percentages, which was the same test as the post-test, lasting 1 hour.

2. Experiment phase: The researcher personally conducted the teaching according to the lesson plan that had been created, with a total experimental duration of 18 hours. The researcher observed the behaviors demonstrated by students during the learning process in each lesson plan.

3. Post-experiment phase: After the experiment was completed, the researcher conducted the post-test using the same test as the pretest on learning achievement in ratios and percentages, lasting 1 hour. The researcher also assessed students' mathematical problem-solving ability using the problem-solving ability test during the learning process, lasting 1 hour. Additionally, students were asked to complete the student satisfaction questionnaire regarding the activity-based learning with higher-order questioning. The data

obtained was then analyzed using statistical methods including the mean (M), standard deviation (SD), and dependent t-test.

Research results

Part 1: Comparison of the Learning Outcomes in Mathematics of Grade 6 Students Before and After Learning through Activity-Based Learning Combined with High-Level Questioning

The researcher designed a 20-item multiple-choice test on the topics of percentage and ratios, where students were asked to take the test before and after the learning process using activity-based learning combined with high-level questioning. The results showed that the Grade 6 students who participated in the learning process using activity-based learning combined with high-level questioning had a significantly higher post-learning result ($M = 14.13$, $SD = 3.61$) than their pre-learning result ($M = 6.50$, $SD = 1.45$) with statistical significance at the .05 level. This finding is consistent with Research Hypothesis 1, which states that after learning through activity-based learning combined with high-level questioning to enhance mathematical problem-solving skills, the Grade 6 students' mathematics learning outcomes would be higher than before the learning process. The detailed results are presented in Table 1.

Table 1: Comparison of the Mathematics Learning Outcomes of Grade 6 Students Before and After Learning through Activity-Based Learning Combined with High-Level Questioning.

Testing	n	Full score	M	SD	t
Pretest	14	20	6.50	1.45	*9.81
Post-test	14	20	14.13	3.61	

** Statistic significant at .01 level

Part 2: Comparison of Problem-Solving Ability in Mathematics

The researcher assessed the problem-solving ability in mathematics of 14 Grade 6 students, using a 5-item test on percentage and ratio, with each item worth 12 points, for a total of 60 points, before and after learning through activity-based learning combined with high-level questioning. The results showed that the problem-solving ability of Grade 6 students who participated in activity-based learning combined with high-level questioning was significantly higher after the learning process ($M = 50.21$, $SD = 5.51$) than before ($M = 29.43$, $SD = 0.94$), with statistical significance at the .05 level. This finding is consistent with Research Hypothesis 2, which states that after learning through activity-based learning combined with high-level questioning to enhance mathematical problem-solving skills, the Grade 6 students' ability to solve mathematical problems would be higher than before the learning process. The detailed results are presented in Table 2.

Table 2: Comparison of Problem-Solving Ability in Mathematics of Grade 6 Students Before and After Learning through Activity-Based Learning Combined with High-Level Questioning.

Testing	n	Full score	M	SD	t
Pretest	14	60	29.43	0.94	*15.52
Post-test	14	60	50.21	5.51	

** Statistic significant at .01 level

Part 3: Results of the Study on the Satisfaction of Grade 6 Students with Activity-Based Learning Combined with High-Level Questioning

The study found that the overall satisfaction of Grade 6 students with activity-based learning combined with high-level questioning was at a very high level ($M = 4.62$, $SD = 0.49$). When considering individual aspects, it was found that students were most satisfied with the organization of learning activities, with the highest level of satisfaction being ranked first ($M = 4.77$, $SD = 0.39$). The next highest satisfaction was in the area of the benefits gained from learning, also at the highest level ($M = 4.71$, $SD = 0.45$). Following that, satisfaction with the learning media was at the highest level ($M = 4.67$, $SD = 0.52$), and lastly, satisfaction with assessment and evaluation was ranked lowest, though still at a high level ($M = 4.33$, $SD = 0.61$). These findings are consistent with Research Hypothesis 3, which states that after learning through activity-based learning combined with high-level questioning to enhance mathematical problem-solving skills, Grade 6 students' satisfaction would increase.

Discussion

From the research results on Activity-Based Learning Combined with High-Level Questioning to Develop Mathematical Problem-Solving Abilities for Grade 6 Students, the results can be discussed as follows:

1. Comparison of the Learning Outcomes in Mathematics on Percentage and Ratio of Grade 6 Students before and after learning through Activity-Based Learning Combined with High-Level Questioning. The post-learning outcomes were significantly higher than pre-learning outcomes at the .05 level, which supports Hypothesis 1. This may be due to the design of the learning process, which focuses on students' active participation, allowing them to learn through hands-on experience, problem-solving in various activities or situations, and collaborating with others to promote thinking and working processes. This aligns with The Institute for the Promotion of Teaching Science and Technology (2017), which proposed that teaching mathematics in the 21st century must adapt to changing environments, social contexts, and technology.

Educators must design learning experiences that prioritize learners, allowing them to learn from real-life situations and be knowledge creators themselves, with the educator sparking interest, facilitating, and creating an environment conducive to collaborative learning. The researcher studied the concepts, theories, and synthesized activity-based learning combined with high-level questioning, which includes 5 steps: 1) Stimulating and reviewing experience, 2) Organizing activities, 3) Exchanging and reflecting on learning, 4) Summarizing knowledge and its application, and 5) Assessment. These 5 learning steps can be applied in the classroom to stimulate learning, allowing

students to learn through various activities in a step-by-step process. The researcher's role is to promote student engagement in activities, focusing on active learning, boosting student confidence to follow the steps, and learning through trial and error, ultimately creating knowledge. This is in line with the Office of the Basic Education Commission (2019), which emphasized that activity-based learning is a new teaching approach that does not focus on rote memorization but on analysis and learning through actual activities (Learning by doing). This leads to better retention and the development of high-order thinking skills, consistent with Worawitthanaleurt (2012) who stated that in activity-based learning, teachers act as facilitators, guiding students to participate in activities rather than simply lecturing.

Moreover, Sithsungnoen, & Chanintarapum (2021) explained that activity-based learning encourages students' active involvement in learning through activities, without focusing on rote memorization but on hands-on experience. This allows students to learn by doing and discover knowledge independently. In this research, high-level questioning was integrated, including questions that stimulate analysis, evaluation, and creativity. These questions help encourage students' learning and thinking, leading to problem-solving processes. The researcher incorporated these questions at each stage of the learning process, effectively promoting students' thinking skills. When students collaborate in thinking, this leads to diverse answers, mutual learning, and creates a positive learning atmosphere. It also fosters positive attitudes in students, in line with Makanong (2009) who stated that high-level questions should be used in classrooms as they enhance thinking, reasoning, and problem-solving skills. Furthermore, Sutthirat (2011) noted that high-level questions encourage respondents to use their thinking, base answers on previous knowledge and experience, and promote creativity and systematic thinking skills. These questions also allow students to express their opinions and encourage them to solve problems independently. However, it is crucial that educators prepare their lessons thoroughly, as learning materials are key to student learning.

This is consistent with the research of Sagunee & Makanong, (2017) who studied the development of attitudes, achievement motivation, and learning behaviors in mathematics among Grade 9 students using activity-based teaching methods. The findings showed that: 1) The attitudes, achievement motivation, and learning behaviors of students who received activity-based teaching were significantly higher after the learning period than before, at a statistical significance level of .05. 2) The attitudes, achievement motivation, and learning behaviors of students who received activity-based teaching were significantly higher than those of students who received traditional teaching, at a statistical significance level of .05. 3) The learning behaviors of students in mathematics before, during, and after lessons, classified by their attitudes toward mathematics and achievement motivation, showed significant improvement.

This is also aligned with the study by Wongpattanakit., Anna., & Intep. (2022) who researched problem-solving abilities in the topic of basic counting principles for Grade 11 students using open-ended teaching methods combined with high-level questioning. The results showed that students' problem-solving abilities were significantly higher than the 70% benchmark at the .05 significance level.

2. Comparison of Mathematical Problem-Solving Ability of Grade 6 Students
The study on the comparison of the mathematical problem-solving abilities of Grade 6 students, who were taught using an activity-based learning approach combined with high-level questioning, revealed that their mathematical problem-solving abilities were significantly higher after the learning intervention compared to before, at the .05 statistical significance level. This supports the second hypothesis. This improvement may be due to

the development of both problem-solving skills and systematic thinking skills facilitated by the activity-based learning approach and the use of high-level questioning.

When considering the students' abilities in solving mathematical problems, the problem-solving process was divided into four stages: 1) Understanding the problem, 2) Planning the solution, 3) Implementing the solution, and 4) Reviewing and reflecting. The stage where students performed the best was the "Understanding the Problem" stage, where they analyzed the problem statement to distinguish between information given and what the problem was asking for. This means that after reading the problem, students could accurately separate the relevant information and the question in all cases. This could be because students had been continuously practicing problem analysis across various topics.

The next best performance was in the "Planning the Solution" stage. In this stage, the researcher asked students to write their problem-solving plan based on their own understanding. Most students chose to write their solutions in a step-by-step list, likely influenced by the examples given by the researcher and the exercises they had practiced, where they consistently used concise step-by-step problem-solving methods.

The next stage, "Implementing the Solution," showed results close to the "Planning the Solution" stage. This might be due to the students' efforts in writing their problem-solving plan in an ordered manner in the previous stage, which led to a correct method of solving the problem. However, some students still made errors in calculations, leading to mistakes in their final answers.

The stage where students scored the lowest was "Reviewing and Reflecting." This was the stage where students had more difficulty, as they were not able to check their answers systematically. This might be because they lacked the necessary reflective thinking skills. The researcher believes that in addition to the step-by-step learning through activity-based learning, using appropriate high-level questioning is crucial for fostering higher-order thinking skills, which will ultimately lead to better problem-solving abilities.

This is in line with the findings of Mekanong (2016), who summarized the importance of high-level questioning, stating that such questions should be used by mathematics teachers in the classroom as they promote higher-level thinking. This is because students need to use analytical thinking, synthesis, and critical thinking to find correct answers. Consistent use of high-level questioning will familiarize students with these processes and help develop their mathematical thinking. Furthermore, Lowriendee (2017) noted that promoting and developing higher-order thinking skills requires skills in asking questions, which must be prepared in advance and align with the lesson content. The questions should be deep and allow time for students to think before answering. Using deep questioning can foster a cooperative learning environment, including critiquing the process, results, activities, thoughts, and tasks in the classroom. During the learning process, teachers should guide students in systematically solving problems through a four-step process: 1) Understanding the problem, 2) Planning the solution, 3) Implementing the solution, and 4) Reviewing and reflecting.

Additionally, the The Institute for the Promotion of Teaching Science and Technology (2017) stated that when teaching problem-solving processes step-by-step, once students understand the process, teachers should emphasize analyzing various ideas in the "Planning the Solution" stage, as this stage is crucial and challenging for students. This is consistent with the research who studied the effect of activity-based learning combined with cooperative learning on the ability to solve mathematical problems and academic achievement in the topic of linear equations with one variable among Grade 7 students at the Srinakharinwirot University Demonstration School (Secondary Level). The findings

revealed that: 1) The mathematical problem-solving ability of the Grade 7 students after receiving the activity-based learning combined with cooperative learning approach was significantly higher than before at the .01 statistical level. 2) The academic achievement of the Grade 7 students after receiving the activity-based learning combined with cooperative learning approach was significantly higher than before at the .01 statistical level. 3) The mathematical problem-solving ability of the Grade 7 students after receiving the activity-based learning combined with cooperative learning approach met the 70% benchmark with statistical significance at the .01 level. 4) The academic achievement of the Grade 7 students after receiving the activity-based learning combined with cooperative learning approach met the 70% benchmark with statistical significance at the .01 level.

Additionally, the research by Jangan, Promluang, & Tantinai (2023) examined the effects of problem-based learning combined with high-level questioning on mathematical problem-solving abilities and academic achievement in mathematics among Grade 6 students. The findings revealed that: 1) The mathematical problem-solving ability of Grade 6 students who received the problem-based learning (PBL) approach combined with high-level questioning was significantly higher than the 70% benchmark at the .05 statistical level. 2) The academic achievement of Grade 6 students who received the problem-based learning (PBL) approach combined with high-level questioning was significantly higher than the 70% benchmark at the .05 statistical level.

3. The study on the satisfaction of Grade 6 students towards the activity-based learning combined with high-level questioning revealed that, overall, the students expressed the highest level of satisfaction. This is consistent with the third research hypothesis. In the learning activities, it was found that the use of activity-based learning combined with high-level questioning is a learning approach that deviates from traditional teaching methods. This has led to increased student engagement, a sense of challenge, and the development of thinking and collaboration skills in a systematic manner. Teachers play an essential role in stimulating thinking and appropriately facilitating various activities. Additionally, using engaging learning materials helps enhance understanding of the content. The assessment methods used were diverse, including before, during, and after the lesson, focusing on student development rather than merely judging students. When students understand and recognize the importance of the content, they can apply the knowledge in their daily lives. Moreover, positive attitudes towards learning mathematics are cultivated. It is evident that effective learning results from the careful planning of the learning process, which promotes students' full potential. Emaikwu (2012) stated that in mathematics teaching, instructors should shift the focus from teaching to student learning. Teachers should provide opportunities for students to think independently so that they can make significant discoveries by themselves. This process helps students understand the key principles of mathematical concepts and equips them with necessary skills and processes for the subject. This aligns with the research of Songputhipanya, Kongkham, & Iam-saard (2023) which studied the development of analytical thinking skills using activity-based learning for Grade 9 students. The results showed that: 1) The ability to analyze before and after learning through activity-based learning significantly improved after the lesson at the .05 level. 2) The satisfaction of Grade 9 students towards activity-based learning was overall at a high level.

Conclusion

The learning process that uses activity-based learning combined with high-level questioning can be considered as proactive learning, which is suitable for learners in the 21st

century. This approach aims to promote learning through hands-on experience, allowing learners to practice various processes through active engagement. It fosters collaboration with others through group activities. In this approach, the teacher shifts their role to facilitate the activities and support the learning process, rather than merely transmitting knowledge. Using diverse high-level questions stimulates learners' thinking at various levels, promoting critical and in-depth thinking skills. This, in turn, enhances problem-solving abilities, which is a key characteristic expected of learners in the 21st century. These problem-solving skills not only contribute to academic development but also enhance life skills that learners can apply effectively in their work and daily lives.

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