THE STUDY OF STUDENTS' METACOGNITION IN PROBLEM-SOLVING-BASED MATHEMATICS CLASSROOM

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Abstract

This study aimed to study students' metacognition in the mathematics classroom using a problem-solving approach. This study employed qualitative research methodologies. The target group for this study was 21 second-grade students at PPAO Ban Talat Nuea School (Wan Kru 2502), under the Phuket Provincial Administrative Organization, Phuket Province, during the second semester of the 2024 academic year. *Purposive sampling* was used. Lesson plans, cameras, video cameras, and field notes were among the study tools. The second semester of the school year 2024 was when the data was gathered. Protocols and descriptive analysis were used to analyze the data in accordance with Garofalo and Lester's (1985) conceptual framework.

The results revealed that students' metacognition was as follows: 1) Orientation: students read, evaluate, and make predictions about several ideas that could be applied to solve the challenges. 2) Organization: students use their anticipated ways to tackle challenges. 3) Execution: Students exhibit mathematical ideas relevant to the given challenge. 4) Verification: students determine that the ideas relevant to the problem situations are appropriate by contrasting and comparing their own ideas with those of their peers.

Keywords*: Metacognition, Problem-solving classroom, Lesson study, Open Approach*

Introduction

A key component of problem-solving, metacognition affects cognitive behavior throughout the entire problem-solving process. Metacognition is associated with elements pertaining to beliefs and attitudes in addition to driving cognitive behavior (Schoenfeld, 1987). Metacognition is used to assess how well problem-solving skills are acknowledged, and task completion is tracked (Garofalo & Lester, 1985). To understand what metacognition is, the components of metacognition can be considered according to Flavell's (1979) concept, which divides metacognition into two parts: cognitive ability, which includes the capacity to plan, direct, monitor, check, and assess the efficacy of one's own learning strategies as well as the capacity to independently choose suitable learning strategies for acquiring long-term understanding. An important role in the problem-solving approach is that students solve problems by themselves. Problem-

solving approaches are content- and process-based approaches to learning, empowering students to learn independently (Isoda & Katagiri, 2012). Process-based approaches provide students with the opportunity to invent and develop new mathematical concepts and approaches on their own. Therefore, instruction begins with students working individually to solve a problem using their mathematical knowledge. After solving a problem, students bring their ideas and problem-solving strategies to the class for discussion. The teacher then leads students in a discussion and comparison of their individual ideas and problem-solving strategies. Whole-class activities provide students with the opportunity to develop both conceptual and process-based mathematical competencies (Takahashi, 2006).

In Thailand, Inprasitha (2022) adapted the Japanese lesson study and open approach into the Thai context since 1999. In the first period, he tried to implement an open approach as open-ended problems to encourage the teachers to recognize that their students were enabled to think by themselves. In the second period, he implemented an open approach in the school context by incorporating lesson study, Transformative Lesson Study incorporated with Open Approach model (TLSOA), as an educational innovation. These innovation enables to development of both students' mathematical thinking and teachers' practices (Inprasitha, 2023). Therefore, a classroom using the TLSOA model was appropriate to study students' metacognition.

Conceptual Framework

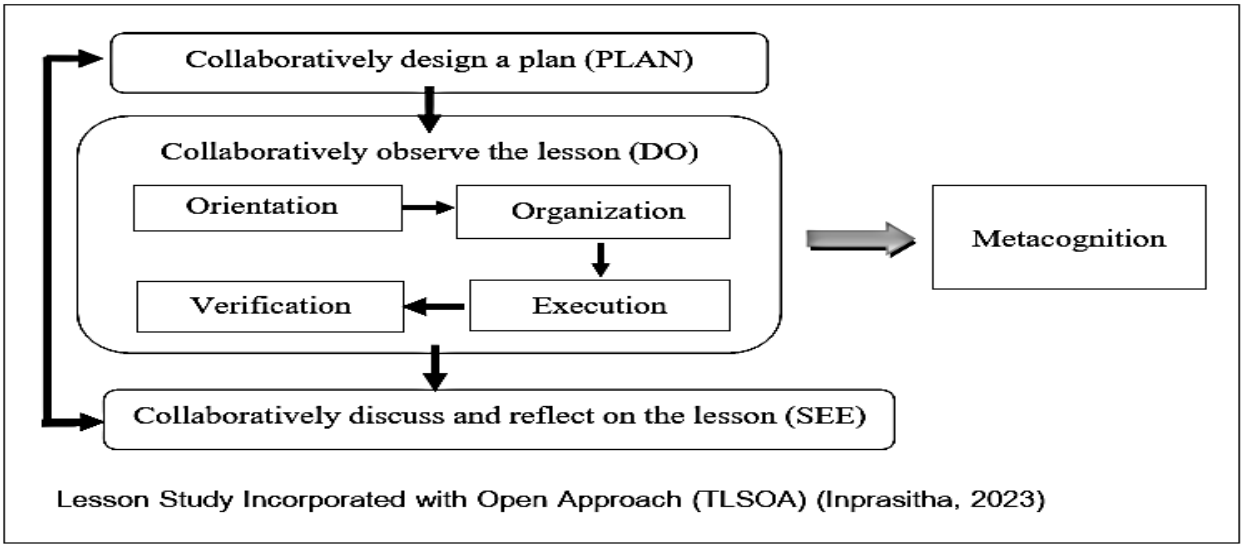


***Figure 1*:** Metacognition in the classroom using TLSOA model

Source: Nuengruthai Nhulung, 2024: The process of studying students' metacognition in mathematical classroom.

Research Objectives

To study students' metacognition in the mathematics classroom using problem-solving approach.

Research Methodology

Target Group: The target group for this study was 21 second-grade students at PPAO Ban Talat Nuea School (Wan Kru 2502), under the Phuket Provincial Administrative Organization, Phuket Province, during the second semester of the 2024 academic year. Purposive sampling was used.

Research tools: This research is qualitative. The research tools are as follows:

1. Learning Plan: The process of creating and developing a learning management plan has the following details: 1) Analyze students' mathematical concepts from mathematics textbooks published by Gakko Tosho, Japan; 2) Design problem situations and teaching media; 3) Predict students' mathematical concepts; 4) Determine teaching sequ ences according to the open-ended teaching method; 6) Take the designed lesson plans to teach in real classrooms with teachers or students practicing teaching in the educational institution as teachers; and 7) reflect on teaching results with experts to analyze students' mathematical concepts and improve learning management for the next class period.

2. Field Notes: used to record student behavior and speech that occur in the classroom using lesson study and open approach classroom learning.

3. Video recorder: used to record the movement and sound of the lesson study team while planning the lesson plan and recording from the beginning of the teaching activity until the end of the summary by linking students' mathematical concepts that emerged in the classroom and the weekly teaching reflection period.

4. Voice Recorder: recorded the lesson study team's voices while they planned the lesson plans, the teacher and students as they delivered lessons, and the lesson study team's voices during weekly reflections.

5. Camera: used to record still images according to the steps of the lesson study and record events in the classroom according to the teaching steps of the open approach, including images of student work and images of the classroom board.

Data Collection: The researcher conducted data collection according to the process of transformative lesson study incorporated with an open approach: 1) collaborative plan, 2) collaboratively do, and 3) collaborative see. The data were recorded using video, still images, audio recordings, and field notes.

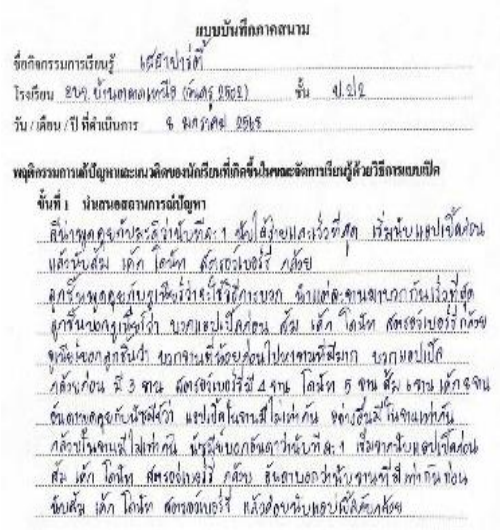
Data Analysis: The data obtained from this study were qualitative, consisting of student work, protocols, and field notes. The researcher analyzed the data using protocol analysis to demonstrate students' metacognition and content analysis, following the conceptual framework of Garofalo and Lester.

Research Results

Results of the Student's Metacognition: Analysis of the Fun Party Activity. This lesson aims to help students understand the meaning of multiplication through an exploration scenario involving equal group members. The problem situation is "Teacher organizes a Children's Day activity. I have snacks and fruit. What do you have and how many?" and the instruction "Students, show how to find the quantity of each type of bread and fruit using the simplest method." At the beginning of the lesson, the teacher presents the problem

situation by displaying a picture of the problem situation and instructions on the board. Then, the teacher distributes a worksheet to each student. Each student solves the problem independently. The teacher observes and records the ideas generated. The teacher selects students' different ideas and presents them to the class. At the end of the lesson, the teacher asks students to jointly summarize the most appropriate ideas for the problem situation. The results of the analysis of students' metacognition are as follows:

1. Orientation: When the teacher presented a problem situation and instructions, students responded to the instructions of the problem situation by discussing together the items and ideas they would use to solve the problem, as shown in Figure 2.



- "S1 talked to S7 about counting by one, which is the easiest and fastest way to count. Start by counting apples, then oranges, cake, donuts, strawberries, and bananas."

- "S2 talked to S3 about using the addition method, adding each dish together as quickly as possible. S2 told S3 to add apples first, oranges, cake, donuts, strawberries, and bananas. S3 told S2 to add the smaller dishes first, then the larger dishes. Add apples and bananas first. There are 3 dishes, strawberries 4, donuts 5, oranges 6, and cake 8."

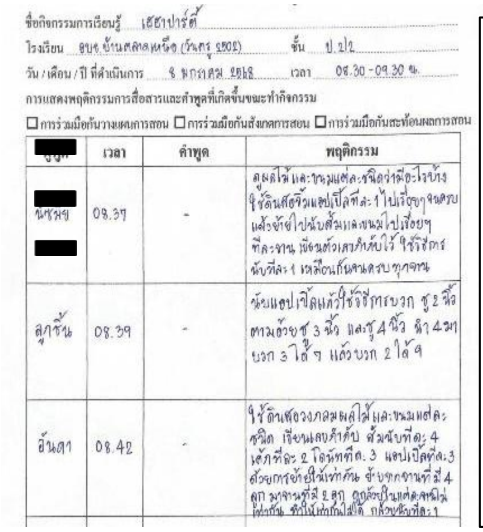
- "S4 talked to S9 about the different number of apples on each dish, the same number of other dishes, and the same number of bananas on each dish. S9 told S4 to count by one, starting with apples, oranges, cake, donuts, strawberries, and bananas. S4 told S9 to count the same number of dishes first, then count oranges, cake, donuts, strawberries, and bananas. Then count the apples and bananas."

***Figure 2*:** shows the fieldwork notes of The Fun Party Activity.

Source: Field notes recorded by the researcher of The Fun Party Activity.

From Figure 2, it can be seen that students displayed different understanding problem situation comprehension behaviors. S1 and S9 tended to find the number of apples by counting *one by one*, which most students in the class used this concept. S2 and S3 tended to count the apples and then use *the repeated addition method*. Meanwhile, S4 was the only student who saw the idea of counting the objects in equal groups: "*Count the plates with equal amounts first, then count the oranges, cakes, donuts, and strawberries.*" It can be seen that in this class, students distinguished the conditions of the instructions and decided to choose the method they thought was most appropriate for them, demonstrating their decision-making in determining their own problem-solving orientation.

2. Organization: Based on the students' different orientations. Students discuss the existence of objects in the picture, leading to students' self-organization of work, as shown in Figure 3.



ชื่อกิจกรรมการเรียนรู้ เฮฮาปาร์ตี้
โรงเรียน อบจ.บ้านตลาดเหนือ (วันครู 2502) ชั้น ป.2/2
วัน/เดือน/ปี ที่ดำเนินการ 8 มกราคม 2568 เวลา 08.30 - 09.30 น.
การแสดงพฤติกรรมการสื่อสารและคำพูดที่เกิดขึ้นขณะทำกิจกรรม
☐ การร่วมมือกันวางแผนการสอน ☐ การร่วมมือกันสังเกตการสอน ☐ การร่วมมือกันสะท้อนผลการสอน

[redacted]	เวลา	คำพูด	พฤติกรรม
[redacted] นิชนย [redacted]	08.37	-	ดูผลไม้และขนมแต่ละชนิดว่ามีอะไรบ้าง ใช้ดินสอจิ้มแอปเปิ้ลทีละ 1 ไปเรื่อยๆจนครบ แล้วย้ายไปนับส้มและขนมไปเรื่อยๆ ทีละจาน เขียนตัวเลขกำกับไว้ ใช้วิธีการนับทีละ 1 เหมือนกันจนครบทุกจาน
ลูกชิ้น	08.39	-	นับแอปเปิ้ลแล้วใช้วิธีการบวก ชู 2 นิ้ว ตามด้วยชู 3 นิ้ว และชู 4 นิ้ว นำ 4 มาบวก 3 ได้ 7 แล้วบวก 2 ได้ 9
อันดา	08.42	-	ใช้ดินสอวงกลมผลไม้และขนมแต่ละชนิด เขียนเลขกำกับ ส้มนับทีละ 4 เค้กทีละ 2 โดนัททีละ 3 แอปเปิ้ลทีละ 3 ด้วยการย้ายให้เท่ากัน ย้ายจากจานที่มี 4 ลูก มาจานที่มี 2 ลูก ดูกล้วยในแต่ละจานไม่เท่ากัน ซึ่งไม่เท่ากันไม่ได้ กล้วยนับทีละ 1

- "S9, look at each fruit and snack, what's in it. Use a pencil to poke one apple at a time until you've finished. Then, move on to counting oranges and snacks, one plate at a time. Write down the numbers. Use the same counting method, one at a time, until you've finished counting all the plates."

- "S2, count the apples and then add two fingers, then three, then four. Add 4 to 3 to get 7, then add 2 to get 9."

- "S4, circle each fruit and snack with a pencil and write down the numbers. Count oranges by 4, cakes by 2, donuts by 3, and apples by 3. Move them evenly, moving from a plate with 4 to a plate with 2. Note that the bananas on each plate are not the same size. They can't be counted evenly. Bananas are counted by 1."

***Figure 3*:** shows the student behavior of The Fun Party Activity.

Source: Field notes on the student behavior recorded by the researcher of The Fun Party Activity.

Figures 2 and 3 demonstrate how students' organization. S9 counted the number of items on each plate by one, while S2 counted the number of items on each plate and added them together, and S4 counted the same number of items in equal increments. This demonstrates behavior that follows a self-determined orientation. Students plan solutions to achieve their desired goals.

1. Execution: Afterward, students began implementing the organization of their plans to achieve their goals, which were reflected in the following concepts that emerged in the classroom.

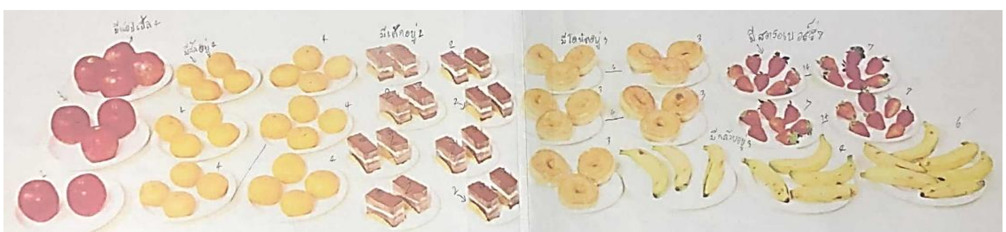


***Figure 4*:** Student concepts using the counting one by one method.

Source: S9's work on The Fun Party Activity.

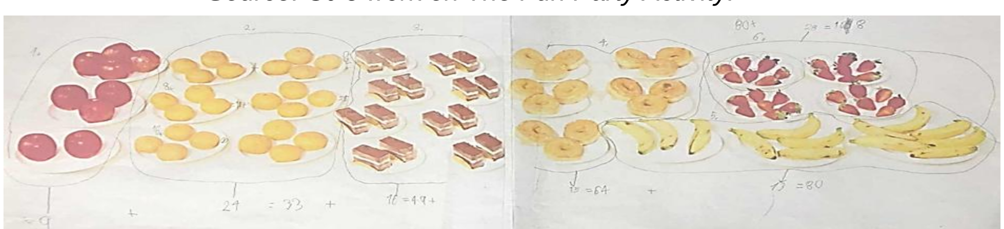


***Figure 5*:** Student Concepts Using the Addition Method

Source: S2's work on The Fun Party Activity.

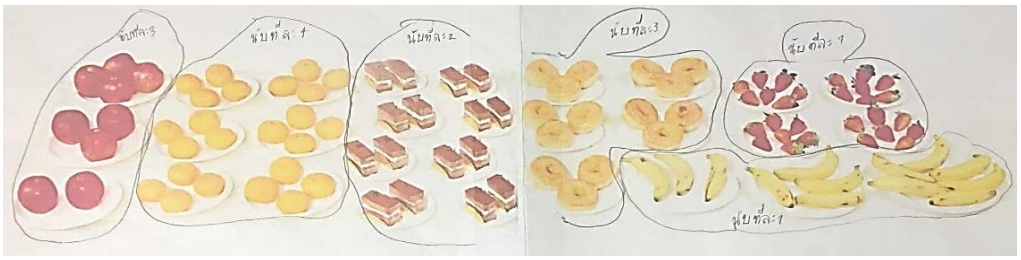


Figure 6: *Student Concepts Using Equal Counting*

Source: S4's work on The Fun Party Activity.

As shown in Figures 4-6, the students implemented the problem-solving method according to the plan. The first idea, students used the one-by-one counting method. The second idea is that students use the one-by-one counting method. The final idea, the student used the equal counting method. This demonstrates the achievement of the goal through implementing their plan.

2. Verification: After students successfully solved the problem situation on their own, according to the plan. The teacher encouraged students to discuss and express their opinions on the methods of counting items presented by their peers in class, as follows:

Item 78	S3	:	How do you count from 3 to 9?
Item 79	T	:	Um, how do you count? 3 at a time for S4.
Item 80	S4	:	*Count 3, 6, 9.*
Item 81	S2	:	*The first one isn't even on the plate.*
Item 82	T	:	Hey, look at your friends.
Item 83	S4	:	*(Goes to move the apples in front of the class.)*

From Items 78-83, S2 and S4 jointly discussed the concept of counting apples by threes. Since the number of apples on each plate was not the same, S2 posed a question to probe the origin of the idea, as in Protocol Item 81, "*The first one on the plate is not the same size.*" S4 countered by explaining his idea by demonstrating moving apples from each plate in front of the class, as in Protocol Item 83, "*(Go move the apple in front of the class).*" S4's actions allowed S2 to examine the idea and determine its origin. As shown in Figure 7.

Figure 7**:** Shows how to move the apples in front of the class.

Source: The researcher recorded S4's picture to move the apples on The Fun Party Activity.

From the discussion above, the teacher facilitated the learning process while the students expressed their own opinions. S2 argued with S4 that it was impossible to count the apples equally because there were unequal numbers of apples on each plate, and S4 argued that it was possible to make the number of apples on each plate equal. The teacher facilitated this by using a visual aid: a picture of apples on a plate, allowing S4 to move the apples to create an equal number, which S2 observed.

Analysis of the fun party activity revealed students' behaviors: orientation, organization, execution, and verification. These four behaviors demonstrate metacognition of problem-solving-based classroom thinking.

Research Suggestions

1. Suggestions for Application of the Findings: This research was conducted in a classroom context using an innovation of lesson study incorporated with open approach, which has unique characteristics. Therefore, the application of the findings should take context into account.

2. Suggestions for Future Research: Factors affecting students' metacognition should be studied in terms of the role of teachers.

Conclusion

The research results found that students' metacognition in mathematics classes emphasized problem solving using innovative classroom education with open methods, as follows: 1) Orientation: Students read and analyze given problem situations and predict various concepts that could be used to solve the problems. 2) Organization: Students solve problems based on their anticipated approaches. 3) Execution: Students demonstrate mathematical concepts appropriate to the problem situation. 4) Verification: Students compare and contrast their own concepts and those of their peers and conclude that the concepts appropriate to the problem situation are appropriate.

Classrooms implementing the innovation of TLSOA model represent a distinctive model of learning management, utilizing a weekly cycle as a key mechanism for systematically improving instructional quality. Teachers collaborate through lesson planning, classroom observation, and reflective discussion to effectively promote students' metacognition. The Open Approach plays a crucial role in developing students' abilities in analytical thinking, problem-solving, and mathematical reasoning, while also encouraging independent learning, offering diverse problem-solving strategies, and enhancing skills in mathematical communication and collaborative work. Furthermore, this innovation fosters a positive learning environment that supports the development of higher order thinking skills and cultivates a sustainable, positive attitude toward mathematics learning.

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