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Analysis of Students' Mathematical Discourse through LKPD-Assisted Commognitive Framework at Ban Kadeng School, Thailand

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Abstract: This study aims to analyze students' mathematical discourse through commognitive framewok assisted by LKPD at Bankadeng School Thailand. The study used a descriptive qualitative approach with data sources in the form of 14 student LKPD. Data collection was carried out through documentation and analyzed using the Miles and Huberman model which included data reduction, data presentation, and conclusion drawn. The analysis focused on four commognitive components, namely word use, visual mediators, routine and narrative. The results showed that the visual components of mediators and routines appeared in all LKPD (100%) which indicated consistency in the use of mathematical representations and procedural completion steps, while word use appeared in 57.14% of students indicating that the use of mathematical language was still limited. The narrative component appeared in 78.57% of students, indicating that most students had started to provide written explanations even though they were not evenly distributed. Overall, students' mathematical discourse is still dominated by procedural practice, but has been in the transitional stage towards argumentative practice. These findings suggest that LKPD-assisted learning facilitates the use of visual representations, solving procedures, and begins to encourage the emergence of mathematical explanations, although reinforcement of mathematical language and argumentation is still.

Keywords: Ban Kadeng school; Commognitive framework; LKPD; Mathematical discours; Thailand

Introduction

Mathematics learning in the 21st century has undergone a significant shift from a teacher-centered approach to learning that puts students at the center of learning activities (Anim et al., 2023; Carney, 2022). This change demands the active involvement of students in building knowledge through interaction, communication. as well as the development of mathematical reasoning and argumentation in the learning process (Francisco, 2022). In this context, mathematical discourse is one of the important aspects in modern mathematics learning (Maanu et al., 2025).

Mathematical discourse is a strategy used by students in using language, symbols, visual representations and reasoning in creating mathematical understanding (Dzulfikar et al., 2025). This concept makes learning mathematics a communication, not just a procedural calculation process (Azzahanty et al., 2023). In the modern learning era, the success of learning mathematics is no longer measured by the correct answers, but also by how the person explains the process of thinking logically and systematically (Lessing et al., 2026).

Along with that, the National Council of Teachers of Mathematics (NCTM 2022) also emphasizes that mathematical communication is one of the important

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standards in mathematics learning. This ability refers to the ability of students to express mathematical ideas orally and in writing, and to develop understanding from mathematical discussions and interactions (Ayalon et al., 2024; Planas et al., 2024). According to Lestari et al. (2024) Mathematical communication skills are important competencies that make it easier for students to understand and convey mathematical ideas effectively in 21st century learning. In addition, mathematics not only functions as a thinking tool, but also as a means to convey ideas clearly and precisely (Siregar et al., 2024).

In previous research, it was known that there were still many students who were not able to communicate and do mathematical reasoning well. Based on several studies, mathematical communication plays a very important role in helping students to present and build mathematical ideas (Wirawan et al., 2026). This is because students who involve themselves in mathematical communication usually have a deep understanding of concepts (Sari et al., 2024; White et al., 2025). Therefore, learning practices in schools still focus more on procedural solutions than mathematical reasoning and argumentation (Bozkurt et al., 2024).

The Programme for International Student Assessment (PISA 2022) report shows that students in the Southeast Asian region, including Thailand, still have difficulty communicating their mathematical reasoning (OECD, 2022). This condition shows that mathematics learning still tends to focus on one-way knowledge delivery so that students have not gained enough space to express their thought processes.

In the Thai context, although the national curriculum has emphasized the importance of critical thinking and communication, its implementation in the classroom still faces various obstacles (Saengrith et al., 2022). This study concludes that some students face difficulties in understanding and composing mathematical arguments influenced by factors of initial ability, language and cultural background (Lubis et al., 2024). This illustrates that students are not fully able to develop mathematical discourse optimally.

To analyze how students construct mathematical discourse, this study uses Commognitive Framework developed by Sfard (Dzulfikar, 2025). In Framework This thinking is a form of communication and learning of mathematics as a participation in mathematical discourse (Zayyadi et al., 2023). This discourse consists of four basic components, namely: Word Usage (use of the word), Visual Mediators (visual mediator), Routines (routine) and narrative (Hakim et al., 2024). These four components are used to analyze how students use language, representation, and reasoning in mathematics.

One of the efforts that can be made to support the development of students' mathematical discourse is through the use of Student Worksheets (LKPD) (Misrawati et al., 2025). Student Worksheets are sheets that contain assignments or activities that students must do (Kurniawan et al., 2026). Learner worksheets serve as an effective medium in supporting mathematical discourse by providing a framework of tasks that encourage students' active involvement in communication, according to the framework Commognitive Framework by Sfard (Sari et al., 2024; Zayyadi et al., 2023).

The LKPD motivates students to write a description of the process and include the reasons why they chose a particular course of action (Januarti et al., 2024; Munandar et al., 2024; Quennerstedt, 2022), so that the four components of this discourse are actively used in learning, namely: Word Usage (use of the word), Visual Mediators, Routines and narrative. Good LKPD design can serve as a catalyst for students' mathematical interaction (Sihombing et al., 2026; Supriyanto et al., 2020). However, existing LKPDs generally only focus on the cognitive aspect (true/wrong answers) and have not been explicitly designed to trigger the four components of discourse commognitive (Melawati, 2020).

Therefore, this study aims to analyze students' mathematical discourse through a framework Commognitive Framework in LKPD-assisted learning at Ban kadeng School, Thailand, with a focus on the four components of discourse, namely Word Usage, Visual mediators, routines and narrative. This research is expected to make a theoretical contribution to the development of the theory commognitive In mathematics education, it is multicultural and practical for teachers to reveal the quality of students' mathematical learning.

Method

Time and Place of the Research

This research was conducted at Ban Kadeng School, Thailand. The research focused on mathematics learning activities involving fraction materials for fourth-grade elementary school students. The research was conducted during the implementation of mathematics learning activities using Student Worksheets (LKPD) as the main learning artifact. The data collection was carried out after the learning process by collecting the original LKPDs completed by the students. The research location was selected because Ban Kadeng School provided an appropriate context for examining students' mathematical discourse practices in solving fraction problems through written learning activities. The research focused on students' written mathematical discourse as reflected in their responses, representations, procedures, and mathematical explanations contained in the LKPD.

Research Design

This research employed a qualitative approach with a descriptive research type and a case study design. The qualitative approach was selected because the research aimed to describe and interpret students' mathematical discourse in depth based on their authentic written work rather than to test a hypothesis or establish a causal relationship. The case study design was used because the research investigated the phenomenon of students' mathematical discourse within a specific educational context, namely mathematics learning on fraction materials at Ban Kadeng School, Thailand.

The research design consisted of the following aspects: (a) Population description, the population in this research consisted of fourth-grade students who participated in mathematics learning involving fraction materials at Ban Kadeng School. (b) Sample size, the research sample consisted of 14 students whose completed LKPDs were collected and analyzed as the primary data source. (c) Sampling technique, the participants were selected using purposive sampling because the students met predetermined criteria relevant to the research objectives, namely participating in the fraction learning activities and completing the LKPD. Purposive sampling is commonly used in qualitative research when participants or data sources are selected because they can provide relevant and information-rich data for understanding the phenomenon under investigation. (d) Research variables, the main focus of the research was students' mathematical discourse, which was analyzed through four components of Sfard's Commognitive Framework: Word Use, Visual Mediators, Routines, and Narratives. (e) Data collection methods, data were collected through documentation by collecting, examining, and analyzing the original student LKPDs, while short classroom observation videos were used as supporting contextual data for triangulation. (f) Tools and materials used in the research, the research instruments consisted of fraction-based Student Worksheets (LKPD) and a Commognitive Coding Sheet. The LKPD was designed to assess students' work on fraction problems and consisted of 22 questions divided into four categories: six equivalent fraction questions, six completing equivalent fraction questions, four fraction simplification questions, and six fraction-to-integer conversion questions. The Commognitive Coding Sheet was used to identify the four components of students' mathematical discourse, namely Word Use, indicated by the use of mathematical terms and symbols; Visual Mediators, indicated by fraction representations; Routines, indicated by the procedures used to solve mathematical problems; and Narratives, indicated by students' mathematical explanations, statements, and arguments.

Research Instruments

Research Instruments in the form of LKPD fractional material which are designed to reveal students' ability to solve fractional problems through 4 categories, namely:

Table 1. Three Question Categories (LKPD)

Yes	Categories	Quantity
1	Fractions of Value	6
2	Complete Fractions of Value	6
3	Fractional Simplification	4
4	Convert Fractions to Integers	6
	Quantity	22 questions

Table 2. Auxiliary Instruments: Commognitive Coding Sheets

Components	Indicator
Word Use	Use of Math Symbols
Visual Mediator	Fractional Representation
Routine	Settlement Procedure
Narrative	Arguments

The data collection technique is carried out through documentation techniques, namely collecting and examining the results of student work in LKPD as a learning artifact. The document is used to identify the form of mathematical communication of students in writing in solving fractional problems.

Data collection using with procedures (1) collection of the original LKPD, (2) digital scanning for preservation, and (3) tringulation with short class observation videos for context documentation (Suhairi et al., 2021).

The data analysis follows the Miles and Huberman interactive model with stages: (1) Data reduction: grouping student answers, coding S1-S14 and coding based on commognive components. (2) Data Presentation: Data is presented in coding tables, percentages and pie charts to illustrate the tendencies of mathematical discourse. (3) Conclusions: Determining the level of students' mathematical discourse and the role of LKPD in learning.

Research Procedure

The research procedure was conducted systematically through several stages, beginning with preparation and ending with data interpretation.

Stage 1: Preparation

At the preparation stage, the researcher identified the research focus, namely students' mathematical discourse in solving fraction problems. The researcher then prepared the fraction-based LKPD according to the learning material and research objectives. The LKPD was designed to provide opportunities for students to demonstrate their mathematical understanding through written responses, representations, procedures, and explanations. At this stage, the researcher also prepared the Commognitive Coding Sheet based on the four components of the Commognitive Framework: Word Use, Visual Mediators, Routines, and Narratives.

Stage 2: Implementation of Mathematics Learning

The next stage was the implementation of mathematics learning at Ban Kadeng School, Thailand. The learning focused on fraction materials and involved fourth-grade students. Students were given the LKPD and instructed to complete the 22 questions individually based on the learning activities and their understanding of the material. During the learning process, the researcher observed the learning context and collected supporting documentation. Short classroom observation videos were also used to provide contextual information regarding the learning activities.

Stage 3: Collection of Student Work

After the learning process was completed, the researcher collected the original LKPDs from the students. A total of 14 LKPDs were collected from 14 students. The original documents were maintained as the primary source of data to ensure that the analysis represented students' authentic written mathematical work.

Stage 4: Digitalization and Organization of Data

The collected LKPDs were digitally scanned to preserve the original documents and facilitate systematic analysis. Each student's document was assigned a participant code from S1 to S14 to maintain consistency during the analysis and protect the identity of the participants. The responses were then organized according to the 22 questions in the LKPD. Thus, 308 student responses were available as units of analysis.

Stage 5: Data Coding

The researcher analyzed each unit of analysis using the Commognitive Coding Sheet. Each student's response was examined to identify evidence of the four Commognitive Framework components. Word Use was identified from the mathematical terms, expressions, and symbols used by students. Visual Mediators were identified from students' use of fraction representations, diagrams, or other visual mathematical representations. Routines were identified from the procedures, strategies, or patterns used by students in solving the problems. Narratives were identified from students' explanations, mathematical statements, reasoning, or arguments supporting their answers.

Stage 6: Data Triangulation

To strengthen the credibility of the findings, the researcher used supporting classroom observation videos as contextual data. The information obtained from the videos was compared with the evidence found in the students' LKPDs. This triangulation was conducted to ensure that the interpretation of students' written mathematical discourse was consistent with the learning context in which the responses were produced.

Stage 7: Data Organization and Interpretation

After the coding process was completed, the coded data were organized into tables. The researcher calculated the frequency and percentage of each Commognitive component found in the students' work. The results were then presented using descriptive tables and pie charts to illustrate the tendencies of students' mathematical discourse. The researcher subsequently interpreted the patterns found in the data to describe the characteristics of students' mathematical discourse in solving fraction problems.

Stage 8: Drawing Conclusions

The final stage was drawing conclusions based on the results of the data analysis. The conclusions were formulated by considering the dominant Commognitive components, the patterns of students' responses, and the characteristics of their mathematical discourse. The findings were used to describe the level and characteristics of students' mathematical discourse and to explain how the use of LKPD supported students' mathematical practices in solving fraction problems.

Research Data Analysis

The data analysis in this research followed the interactive model of Miles, Huberman, and Saldaña, which consists of three main activities: data condensation, data display, and conclusion drawing/verification. The analysis was conducted continuously throughout the research process to obtain a comprehensive description of students' mathematical discourse.

Data Condensation

Data condensation involved selecting, focusing, simplifying, and organizing the data obtained from the students' LKPDs. First, all 14 LKPDs were collected and assigned participant codes from S1 to S14. Second, the answers to the 22 questions were identified and organized, resulting in 308 units of analysis. Third, each response was examined based on the four components of the Commognitive Framework.

The coding process was conducted as follows: Word Use (WU): the researcher identified students' use of mathematical language, terminology, symbols, and expressions related to fractions. Visual Mediators (VM): the researcher identified the use of visual representations such as fraction models, diagrams, or other representations used to communicate mathematical ideas. Routines (R): the researcher identified the procedures, strategies, algorithms, or patterns followed by students when solving fraction problems. Narratives (N): the researcher identified students' mathematical explanations, reasoning, statements, or arguments used to justify their answers.

Data Display

After the data were condensed and coded, the results were displayed systematically in coding tables. The tables showed the distribution of the four Commognitive components across the students' responses. The frequency of each component was then calculated to determine how frequently each form of mathematical discourse appeared in the students' work. The percentage of each category was calculated using the following formula:

$$P = \frac{F}{N} \times 100\% \quad (1)$$

where: P = percentage of the category, F = frequency of the category, and, N = total number of analyzed data or relevant units of analysis.

The results were also presented in the form of pie charts to provide a visual description of the distribution of students' mathematical discourse. The analysis was conducted not only quantitatively in terms of frequency and percentage but also qualitatively by examining examples of students' actual written responses. This qualitative interpretation was important because the purpose of the research was to describe the characteristics of students' mathematical discourse rather than merely calculate the frequency of particular responses.

Conclusion Drawing and Verification

The final stage involved drawing and verifying conclusions from the displayed data. The researcher interpreted the patterns emerging from the four Commognitive components to determine the characteristics of students' mathematical discourse in solving fraction problems.

The interpretation focused on how students used mathematical words and symbols, how they represented fraction concepts visually, what procedures they used to solve the problems, and whether they provided explanations or arguments to support their mathematical answers. The researcher then identified the dominant characteristics of students' mathematical discourse based on the overall patterns found in the 308 units of analysis.

The conclusions were continuously verified by comparing the results of the coding with the original LKPD documents and the supporting classroom observation videos. This process was conducted to ensure that the conclusions were grounded in the actual data and accurately represented the students' mathematical discourse within the context of fraction learning at Ban Kadeng School.

Data Interpretation Based on the Commognitive Framework

The final interpretation was based on the four components of Sfard's Commognitive Framework. The presence of Word Use indicated students' ability to communicate mathematical ideas through mathematical language and symbols. Visual Mediators reflected students' use of representations to support their understanding of fractions. Routines represented the procedures and strategies students used when solving mathematical problems. Meanwhile, Narratives reflected students' ability to explain, reason, or provide mathematical arguments for their solutions.

The combination of these four components was used to describe the overall characteristics of students' mathematical discourse. A discourse dominated by routines and limited narratives, for example, would indicate that students tended to rely on procedural problem-solving rather than providing detailed mathematical explanations or arguments. Therefore, the analysis was directed not only at identifying whether a component appeared but also at understanding the nature and quality of the mathematical discourse demonstrated in students' written work.

Result and Discussion

Research Results

Table 3. LKPD Question Categories

Yes	Categories	Quantity
1	Fractions of Value	6
2	Complete Fractions of Value	6
3	Fractional Simplification	4
4	Convert Fractions to Integers	6
	Quantity	22 questions

Figure 1. LKPD questions

Primary data were obtained from fractional LKPD analyzed from 14 elementary school grade IV students at Bankadeng School, Thailand, selected purposive for representativeness. With question categories as shown in Table 3.

Known: Number of students $n = 14$
Number of Questions $(S = 22)$
So obtained = number of students x Number of questions = 14 x 22 = 308 units of analysis

Using a commognitive coding sheet with four components, namely word use (WU), visual mediator (VM), routine (rt) and narrative (NR)

Results of commognitive coding analysis

Coding Per LKPD Document

Based on table 4 obtained on the Visual Mediator (VM) and Routine (RT) appeared in all student LKPD with a total of 14 findings. Meanwhile, the components Word Usage (WU) only appeared on 9 student LKPDs, namely S1, S6, S7, S8, S10, S11, S12, S13, and S14. Then the components Narrative (NR) only appeared in 12 student LKPDs, namely S2, S3, S4, S5, S6, S7, S8, S10, S11, S12, S13, and S14. Overall, from the data of 14 LKPDs, students obtained the frequency of word use = 9, visual mediator = 14, rountine = 14 and narrative = 12.

Table 4. Coding Results per LKPD Document

Code	WU	VM	RT	NR	Conclusion
S1	no	Yes	Yes	no	Students are able to work on the problem but have not written an explanation
S2	no	Yes	Yes	Yes	Students are able to work on the problem but have not written an explanation.
S3	no	Yes	Yes	Yes	The work steps are quite clear, understanding is moderate.
S4	Yes	Yes	Yes	Yes	All components appear, good ability
S5	no	Yes	Yes	Yes	Good and complete mathematical communication
S6	no			no	Focus on the final result, explanation is still lacking
S7	Yes	Yes	Yes	Yes	Systematic and complete
S8	Yes	Yes	Yes	Yes	Good conceptual understanding
S9	no	Yes	Yes	no	Dominant symbols and procedures only
S10	Yes	Yes	Yes	Yes	Demonstrate good understanding
S11	Yes	Yes	Yes	Yes	The steps are clear and correct
S12	Yes	Yes	Yes	Yes	The explanation is still low, only the final result.
S13	Yes	Yes	Yes	Yes	Complete and systematic
S14	Yes	Yes	Yes	Yes	All components appear well
Quantity	8	14	14	11	

Frequency Recapitulation

For more details, you can see figure 3. Based on Figure 2 of the Frequency Recapitulation Diagram, the word use component obtained a frequency of 9 with a percentage of 57.14%. This shows that more than half of the students have started using mathematical words, terms or language in solving problems, such as the use of fractional terms, numerators, denominators, times and divisions. However, this percentage is still relatively moderate, showing that some other students are not used to expressing mathematical ideas in writing.

The Visual Mediator component acquires a frequency of 14 with a percentage of 100%. This means that all students use visual representations of mathematics in the form of numbers, symbols of counting operations, fractional lines and other forms of mathematical notation. This shows that younger students understand and convey mathematical concepts through symbols or visual representations than through written language.

Table 5. Frequency Recapitulation

Components	Frequency	Percentage
Word Use	9	57.14%
Visual Mediator	14	100%
Rountine	14	100%
Narrative	11	78.57%

The Routine component acquires a frequency of 14 with a percentage of 100%. This shows that all students are able to carry out procedures or steps to solve questions according to the rules that have been learned. Students can solve problems by calculating, simplifying fractions and determining fractions of value. Thus, students' procedural skills are classified as very good.

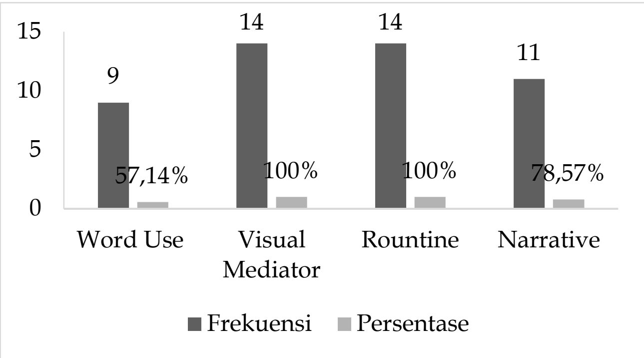

Figure 2. Frequency recapitulation diagram

The Narrative component received a frequency of 11 with a percentage of 78.57%. These results show that most students are able to write explanations, reasons or steps to solve the problem even though it is still simple. However, there are still some students who only write the final answer without giving an explanation of their thinking process.

Overall, the results of the analysis showed that the most dominant student abilities were in the visual components of mediators and routines, while the word use component was still the lowest. This means that students tend to be more able to use mathematical symbols and solve procedural problems rather than communicating mathematical ideas through written language.

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Discussion

This study aims to analyze students' mathematical discourse through Commognitive Framework in LKPD-assisted learning at Ban Kadeng School, Thailand. The results showed that the mediator and routine visual component components appeared consistently in all LKPDs (100%), while word use only appeared in 8 LKPDs (57.14%) and narrative components appeared in 11 LKPDs (78.57%). These findings provide an idea that students' mathematical discourse is still dominated by procedural practice and has not developed towards argumentative practice.

From the results show: (1) The appearance of the word use component was found in 8 LKPDs (57.14%). This shows that the use of mathematical terms or language appropriately is still limited, so that students' mathematical communication skills through language have not developed optimally. (2) The visual component of the mediator appeared on 14 MFFIs (100%). This shows that all students have utilized symbols, notation, or mathematical representations in the completion process, so that the representational aspect in the student's mathematical discourse has developed well. (3) The routine component appeared in 14 LKPD (100%). This shows that students are used to following the steps of solving procedurally, so that procedural practice becomes a very dominant part of students' math activities. (4) The Narrative component appeared in 11 LKPDs (78.57%). This shows that most students have started to write down mathematical explanations or reasons, but the ability to provide justification is not consistent for all students.

Based on the overall results of the research, students' mathematical discourse can be categorized as being at a procedural stage that is transitional to argumentative practice. This is shown by the word use component (57.14%). This is in accordance with the findings of the research by Planas et al. (2024), and Zhang et al. (2024). shows that mathematical language needs to be taught explicitly in learning so that students are able to communicate mathematical ideas clearly. Components Visual Media (100%). This is in accordance with the findings of Weber et al. (2022) showing that the representational aspect in students' mathematical discourse has developed well. Visual representations are known to play an important role in helping understanding mathematical concepts (Ainsworth, 2022). The routine component (100%) of this condition indicates that procedural practice is still very dominant in students' mathematical activities. This condition shows that students are still in the early stages of mathematical argumentation development (Weber et al., 2022), and narrative components (78.57%), This is in accordance with the findings of the National Council of Teachers of Mathematics (NCTM, 2023) which affirms that the ability to compose mathematical explanations, reasons, and arguments is an important part of mathematics learning to help students build an in-depth understanding of concepts. These findings show that LKPD-assisted learning is able to facilitate the development of students' mathematical discourse at the procedural stage which is tarnissional to argumentative.

Conclusion

Based on the results of the analysis of 14 student LKPDs, several conclusions were obtained as follows: (1) The word use component appears on some LKPDs. These findings show that students' use of mathematical terms and language is not consistent, so mathematical communication skills through language still need to be improved. (2) The visual component of the mediator appears throughout the LKPD. This shows that students consistently use visual representations. (3) The routine component appears on all LKPDs. This shows that students are used to following the steps of solving procedurally, so that procedural practice becomes a very dominant part of students' math activities. (4) The narrative component appears in some LKPDs. These findings show that students' ability to write mathematical explanations or reasons has begun to develop, but has not appeared consistently in all students. Overall, students' mathematical discourse in LKPD-assisted learning is still at the procedural stage which is transitional to argumentative. Learning has facilitated the use of visual representations, the application of completion procedures, and has begun to encourage the emergence of mathematical explanations of students.

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Conflicts of Interest
The authors declare no conflict of interest.

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