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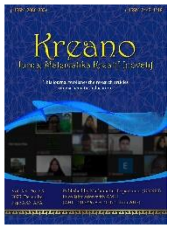

Analysis of Students' Mathematical Communication Ability Errors Based on the Kastolan Stages at Ban Eyoh School Thailand

Sri Wahyuni Lubis[1], Fitriani[1], Ainun Mardiyah Lubis[1], Yulia Anita Siregar[1], and Sakinah Samoh[2]

[1]Universitas Muhammadiyah Tapanuli Selatan, Padangsidimpuan, Indonesia
[2]Ban Eyoh School, Thailand

Correspondence should be addressed to Yulia Anita Siregar: yulia.anita@um-tapsel.ac.id

Abstract

Communication ability is one of the five basic abilities of mathematics. Understanding communication ability is one of the important things in building a learning design suitable for students' ability levels. This study analyzes the mathematical communication based on the Kastolan stages of ability of 6th-grade students at Ban Eyoh School in Thailand in answering fractional arithmetic story problems. Three students who took the sample in the study, S1 scored 94, S2 scored 83, and S3 scored 72, were reviewed for high, moderate, and low communication ability. Students generally have difficulties in presenting steps in writing, especially in explaining what is known and asked about stories. Kastolan stage analysis reveals various conceptual, procedural, and technical errors, including challenges in converting mixed fractions and a lack of coherence in the solution process. Recommendations include a focus on written expression, enhanced conceptual understanding and school facilities support to improve students' mathematical communication ability. By understanding the level of students' communication ability, the results of this research can become the basis for didactical research to develop appropriate learning designs. This research can also be continued with research related to constructive feedback.

Keywords: Error Analysis; Mathematical Communication Ability; Kastolan Stages

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Abstrak

Kemampuan komunikasi merupakan salah satu dari 5 kemampuan dasar bermatematika. Memahami kemampuan komunikasi adalah salah satu hal penting untuk membangun desain pembelajarna yang sesaui dengan level kemampuan siswa. Penelitian kualitatif deskriptif ini menganalisis kesalahan kemampuan komunikasi matematika berdasarkan tahapan kastolan pada siswa kelas 6 di Ban Eyoh School Thailand dalam menjawab soal cerita operasi hitung pecahan. Tiga siswa yang menjadi sampel dalam penelitian, S1 dengan skor 94, S2 dengan skor 83, dan S3 dengan skor 72, ditinjau dari kemampuan komunikasi tinggi, sedang, dan rendah. Siswa umumnya menghadapi kesulitan dalam menyajikan langkah-langkah secara tertulis, terutama dalam menjelaskan hal yang diketahui dan ditanyakan pada soal cerita. Analisis tahapan kastolan menunjukkan berbagai kesalahan konseptual, prosedural, dan teknikal, termasuk kesulitan dalam mengubah pecahan campuran dan kurangnya keteraturan dalam proses penyelesaian. Rekomendasi mencakup penekanan pada aspek tertulis, peningkatan pemahaman konsep, dan dukungan fasilitas sekolah untuk meningkatkan kemampuan komunikasi matematis siswa. Dengan memahami level kemampuan komunikasi siswa, hasil riset ini dapat menjadi dasr riset didaktis untuk mengembangkan desain pembelajaran yang sesaui. Riset ini dapat juga dilanjutkan dengan riset terkait feedback yang membangun.

INTRODUCTION

Mathematics plays an important role in education, providing a strong foundation for the development of students' logical and analytical thinking abilities (Nainggolan, 2023). In addition, mathematical communication ability is a critical aspect of learning, given the complexity of mathematical problems that are often presented in the form of stories (Afifah & Kusuma, 2021). In this context, it is important to understand the extent of students' mathematical communication ability in solving narrative problems of fraction calculation operations.

Learning mathematics is about mastering numeracy ability and students' ability to explain mathematical ideas orally and in writing. (Nasir et al., 2023). Mathematics education is directed to train students to be able to communicate clearly and precisely, use numbers, symbols, tables, or other media in explaining a problem (Sidiq et al., 2023). Therefore, mathematical communication errors, especially in narrative story problems, must be taken seriously.

Mathematics learning is interesting to look at because many students complain about how difficult it is to understand mathematics material (Lathiifah & Agustine, 2023). This happened because, in the learning process, there were still many students who were passive and did not pay attention to the teacher's explanation (Wulandari et al., 2020). So in the learning process, a teacher must pay more attention to students who are in the classroom.

Mathematical Communication is a growing collection of resources to engage students in writing and talking about mathematics, either to learn mathematics or communicate as mathematicians. Speaking, listening, writing, and reading are examined and analyzed with a focus on verbal interactions and aspects of students' written mathematics. It also explores the nature of the mathematical writing system and how students gain access to it. (Aslan, 2021; McKenney & Reeves, 2014; Pimm, 2019)

This research makes a significant contribution to strengthening the theories of previous researchers (Aminah et al., 2018) in exploring through error analysis of students' communication ability in solving narrative problems of fraction calculation operations based on Kastolan's stages. The results of this research not only identify students' errors but also provide valuable insights into the barriers and difficulties they experience. Thus, these findings can be used as an empirical basis for developing and refining theories related to mathematical communication ability, providing a strong foundation for the development of more effective learning strategies in the educational environment.

There are several learning methods used by mathematics teachers at Ban Eyoh School, namely lecture method learning and demonstration method learning. The first is lecture method learning where a teacher explains directly about the learning material in front of the class and the students are asked to listen and understand the things that are being explained by the teacher. After finishing the explanation, the teacher asks one of the students to re-explain what the teacher has explained. After the student finishes explaining the material, the teacher tests the student's abilities by conducting practice tasks. The second learning method, namely the demonstration method, is proven by the teacher demonstrating the exercises that have been answered by students first in front of the class then students must present back in sequence the answers to the exercises that have been given by the teacher in front of the class.

In the background of this research, previous researchers (Nugroho et al., 2023) have identified difficulties in solving narrative problems of fraction calculation operations. Relevant previous studies (Sari & Subekti, 2023) also noted that analysis of one of the students' answers revealed conceptual, procedural, and technical errors, indicating barriers to understanding fraction operations.

In this context, the formulation of the research problem is "How is students' mathematical communication ability in solving narrative problems of fraction calculation operations based on the Kastolan stage for grade VI students at Ban Eyoh School Thailand?" The purpose of this study is to describe students' mathematical communication ability in solving narrative problems of fraction calculation operations based on the Kastolan stage.

According to Syukri (Syukri, 2019), contributes to the understanding of the errors commonly experienced by students in solving narrative problems of fraction calculation operations. The results of the error analysis can provide additional insights for educators and school curricula to design learning strategies that are more in line with student needs.

The importance of mathematical communication ability in solving narrative problems of fraction calculation operations is not only relevant in the scope of formal education but also has an impact on everyday life (Khofifah et al., 2022). In this era of globalization, where the need for individuals who can think critically and communicate ideas effectively is increasing, mastering mathematical communication ability becomes even more important (Amelia, 2023).

Through this research, it is hoped that it can provide concrete solutions to overcome the difficulties faced by students in understanding, solving, and communicating fraction calculation operation narrative problems. The findings are also expected to be the basis for developing more innovative and effective learning methods and can provide input for curriculum development that is more adaptive to student needs.

This research not only benefits students, teachers, and the school at Ban Eyoh School Thailand but can also serve as inspiration for similar research in other schools and educational contexts. Thus, this research not only makes a local contribution but can also play a role in improving the quality of mathematics education more broadly.

By understanding the relationship between students' mathematical communication errors in solving narrative problems of fraction calculation operations and mathematical thinking ability (Pratiwi et al., 2020), It is hoped that this research will make a positive contribution to the development of better mathematics education at Ban Eyoh School Thailand and may also apply to other educational contexts.

METHOD

The introduction outlines how this research needs to be explained. The importance of mathematical communication has been highlighted and therefore, research into students' mathematical communication ability is necessary (Creswell, 2013).

This research adopts a descriptive qualitative approach with the research subjects of all grades VI students at Ban Eyoh School Thailand. The focus is to observe and analyze students' communication ability errors in solving fraction operation narrative problems based on the Kastolan stages. These errors are analyzed through the process of analysis as learning barriers in Brousseau's didactical theory (Brousseau, 2002; Cesaria & Herman, 2019).

Data collection techniques involved writing tests and interviews with students and mathematics teachers. Data analysis included data reduction, presentation of interview results, and conclusion to answer the research problems. Test validity and reliability were measured using the Product Moment correlation coefficient and Cronbach's Alpha. The data collection process was divided into pre-field and field stages, involving the preparation of test instruments, population characteristics, test execution, interviews, observation of students' answers, and data analysis based on the Kastolan stages. The research was conducted in Thailand as a form of collaboration between Indonesia and Thailand.

Data were obtained through a written test consisting of 5 items of fraction calculation operation narrative questions given to 18 students. Each question is given a score with a score range of $85 < n < 100$ in the high score category, $75 < n < 85$ in the moderate score category, and $n < 75$ in the low score category.

Then after obtaining written answers from students, student errors were analysed and then 3 students were selected to be interviewed. The three students were selected based on their abilities, namely: high-ability students (S1), moderate-ability students (S2), and low-ability students (S3). After that, the results of the answers were assessed using indicators of understanding of mathematical concepts according to (Setiawan et al., 2023) which has been modified, namely: (1) Students' ability to connect mathematics with real objects in daily life, indicator A; (2) Students' ability to interpret events that occur in the form of fraction calculation operations, indicator B; (3) Students' communication ability in describing the things that are known in the events that occur in the form of fraction calculation operations, indicator C; (4) Students' ability to evaluate the event and solve the problems in the event, indicator D; and (5) Students' ability to draw conclusions and communicate back the results that have been resolved in the event, indicator E

After analyzing students' communication ability based on indicators of understanding of mathematical concepts, then the students' answers were analyzed again based on their castolanKastolan errors. Errors in working on maths problems based on Kastolan stages namely: (1) **Conceptual Error (KK):** student errors in choosing formulas, students do not answer the questions correctly, and students do not do the problems that have been given; (2) **Procedural Error (KP)**: student errors in solving the problem with the correct steps, students do not simplify the answer to the problem, students do not write the known and questionable information, and students do not answer sequentially solving the problem, and (3) **Technical Error (KT):** students are wrong in calculating numbers, writing mathematical signs of punctuation, and writing coefficient constants and variables.

After producing data that has been analyzed based on indicators of concept understanding and analyzed for errors based on Kastolan stages, then the results of the data are presented by defining the errors made by S1. S2 and S3 are based on communication ability and Kastolan stages.

The research stages are as follows:

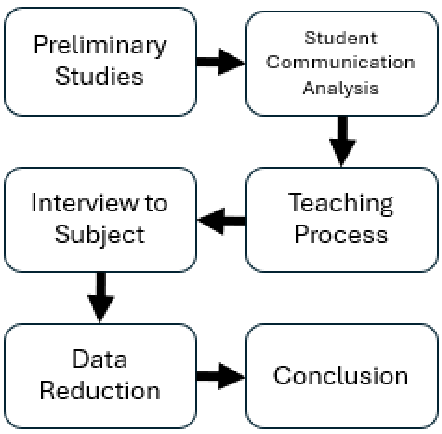


Figure 1. Research step

RESULT AND DISCUSSION

This study was conducted at Ban Kadeng Primary School in southern Thailand. Most of the students in the school are Muslim because Ban Kadeng is in the southern area of Thailand which is adjacent to Malaysia. There are many people of Malay race in the area. Here is the learning situation in the school:

Figure 2. learning situation at the research subject

After learning, students' concept understanding was measured. The following table presents data from the results of research on students with exposure to data analysis as shown in Tabel 1.

Table 1. Results of students' understanding of mathematical concepts.

Subject	Indicators of Concept Understanding				
	Question 1	**Question 2**	**Question 3**	**Question 4**	**Question 5**
S1	B D E	B C D E	B C D E	B C D E	B C D E
S2	C E	B C D E	-	-	B C D
S3	-	B	-	B	B D E

Based on Table 1 above, S1 still does not fulfill indicator A. From question 1 to question 5, no indicator A is fulfilled. It can be defined that S1 has not been able to connect mathematics with real objects in everyday life (Fitriani et al., 2021). Then in question number 1, indicator C is also not fulfilled, which means that S1 has not been able to explain what things are known and asked in the problem. Indicators B, D, and E can be fulfilled by S1 as evidenced by the ability to write and mention the answer to the problem correctly and structured using the fraction operation method, being able to write and reexamine the answers obtained by answering the questions obtained by recalculating, as well as carrying out proof in solving the problem and having written and mentioned the conclusion correctly. Indicators B, D, and E can be fulfilled by S1 as evidenced by the ability to write and mention the answer to the problem correctly and structure using the fraction operation method, being able to write and recheck the answers obtained by answering the questions obtained by recalculating, as well as carrying out proof in solving the problem and having written and mentioned the conclusion correctly.

S2 was unable to fulfill all indicators of concept understanding in questions number 3 and 4. But in question number 1, S2 can understand 2 indicators, namely using the fraction operation method by the concept and mentioning and writing conclusions correctly. In question number 2, S2 is only unable to fulfill indicator A, namely not being able to connect mathematics with real objects in everyday life. And for question number 5, S2 is unable to fulfill indicators A and E, namely not being able to connect mathematics with real objects in everyday life, and not being able to mention and write conclusions appropriately.

The results of student work at the school are as Figure 3.

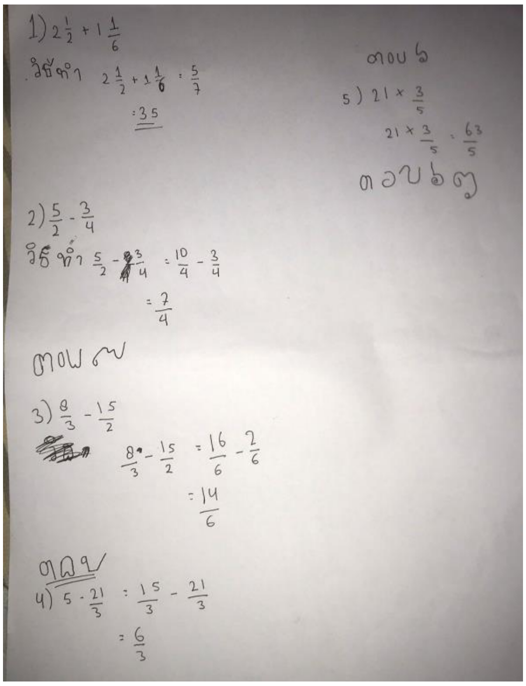


Figure 3. results of student work at school

Then for S3, it seems that he is still unable to fulfill all indicators in questions number 1 and 4, and is only able to fulfill aspect B in questions number 2 and 4. In question number 5, S3 has not been able to fulfill indicators A and C, namely not being able to connect mathematics with real objects in everyday life and explain things that are known in the events that occur in the form of fraction calculation operations.

Furthermore, Ulfa and Kartini (Ulfa & Kartini, 2021) stated a significant contribution to the theoretical understanding of mathematical communication ability, especially in the context of solving story problems of fraction calculation operations based on the Kastolan stage. Student error analysis provides an in-depth look at the aspects that need more attention in the learning process (Dawa et al., 2020). This research investigates the errors in the mathematics communication ability of grade 6 students at Ban Eyoh School Thailand based on the Kastolan stages. The following is a discussion of research on mathematics communication ability errors of grade 6 students at Ban Eyoh School Thailand based on the Kastolan stages as follows.

Table 2. Student-generated question scores based on the accuracy of answering questions

Subject	Score					Total Score
	1	2	3	4	5	
S1	19	18	18	18	17	90
S2	17	16	14	14	15	76
S3	12	13	12	13	15	65

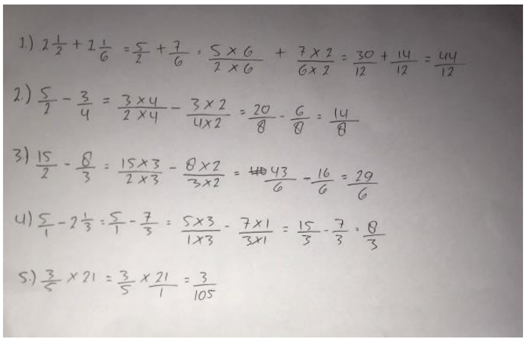
Table 3. Kastolan errors made by students

Subject	Kastolan Error				
	1	2	3	4	5
S1	KP	KP	KP	KP	KP,KT
S2	KK, KP, KT	KP	KK, KP	KP, KT	KP
S3	KK, KP, KT	KK, KP, KT	KK, KP, KT	KK, KP, KT	KP

Based on Table 2 and Table 3 above, S1 shows good ability in understanding and solving fraction narrative problems. (Pangaribuan et al, 2021). S1 showed high mathematical communication ability with a total score of 94. However, there were errors in the procedural aspect, where S1 failed to present in writing what was known and asked in the narrative problem. Technical errors only occurred in problem number 5, where S1 made errors in multiplying fractions, probably due to lack of focus and rushing. Although there were procedural errors due to not putting the steps in writing, students were still able to explain the steps well orally. Although there are some technical errors in the calculation of multiplication in some problems, in general, students understand the concept of fractions well.

S2 showed moderate mathematical communication ability with a total score of 83. S2's main error lies in the conceptual aspect of problem number 1, where S2 is erroneous in converting mixed fractions into ordinary fractions. In addition, S2 tended not to write the things known and asked in the narrative problem. S2 had errors at the conceptual stage in problem number 1, where they made errors in converting mixed fractions. At the procedural stage, S2 often did not write the things known and asked in the narrative problem. Technical errors occurred because they were too hasty in calculating. S2 also showed the ability to convert mathematical statements, although there were technical errors in some problems. (Hasibuan et al., 2022). In general, there are conceptual and procedural errors in understanding the concept of fraction calculation operations. Recommendations for improvement involve further practice in interpreting events, strengthening the understanding of the concept of fraction operations, and practicing speed in calculating thoroughly. With the implementation of these recommendations, S2 is expected to improve his mathematical communication ability and understand the concept of fraction operations better.

Some of the student's work can be seen in the Figure 4 below.



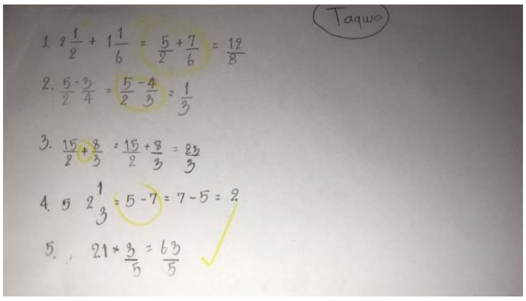


Figure 4. S2 and S3 work

S3 showed low mathematical communication ability with a total score of 72. There were several errors in each aspect of the assessment. In problem number 1, S3 was wrong in choosing the calculation operation and did not simplify the results of the fraction operation. In addition, S3 often failed to write down the things known and asked in the story problem. S3 has errors at each stage of Kastolan. At the conceptual stage, S3 was wrong in choosing the calculation operation. At the procedural stage, S3 failed to present in writing the things known and asked in the narrative problem and did not simplify the answer. Technical errors occur when calculating sums. There are several S3 Kastolan errors, especially in the aspects of conceptual, procedural, and technical errors (Ayu et al., 2023). In overcoming this, more practice and understanding of mathematical concepts, especially in fraction calculation operations, is needed.

This study provides a good insight into students' mathematical communication ability errors at Ban Eyoh School Thailand, focusing on conceptual, procedural, and technical aspects. Recommendations for improvement can focus on strengthening the understanding of basic mathematical concepts and improving students' ability to present answers in writing and simplify the results of fraction operations.

Discussion

There are 4 things found in this study that need to be improved by teachers. The improvement of the teacher's actions can encourage students' mathematical communication ability.

(1) Listening for comprehension, reading comprehension, and recording necessary mathematical information presented in mathematical texts or the speech or writing of others. In the practice found, the teacher still acts formally. Students obtain information from the teacher without acting independently. Finding information independently is important for building communication ability and is in line with some previous research (Aslan, 2021; Clements & Sarama, 2004; Hockings et al., 2018; Livingston, 2012; Polya, 1962; Skemp, 1987).

(2) Presenting, expressing (speaking or writing) mathematical content, ideas, and solutions in interaction with others (with appropriate completeness and rigor). In the learning practice carried out, the teacher still explains too much material. Students are rarely allowed to discuss with friends. However, this cannot be explained further whether the absence of opportunities is because the teacher does not provide opportunities or students are unable to discuss independently. However, this obstacle indicates a problem that needs to be solved further. Providing opportunities for discussion in knowledge formation is important and needs to be done by students to build more permanent schemes (Brousseau, 2002; Chevallard & Bosch, 2020; Dubinsky, 2000; Uyen et al., 2021)

(3) Effectively use mathematical language (numbers, letters, symbols, charts, graphs, logical connections) combined with common language or physical gestures when presenting, solving problems, and evaluating mathematical ideas in interaction (discussing, arguing) with others. In modern development, communication is done verbally. Students can do

this through apps, watching videos, and various other means of communication. Teachers need to improve their ability to operate various modes of teaching so that students can communicate more easily. The process of using these modes by both teachers and prospective teachers is important because it will be able to build communication in students (Assis et al., 2018; Gonzales et al., 2020; Graham et al., 2020; Önal, 2019; Uyen et al., 2021; Vogt & Rogalla, 2009).

(4) Showing confidence when presenting, expressing, asking questions, discussing, and debating ideas related to mathematics. In the practice that has been done, teachers still need to build students' confidence. Teachers need to provide sufficient motivation to students. One way is to provide opportunities for students to conduct inquiry and student-centered learning. This is certainly in line with some research on students' self-efficacy and confidence in mathematics (Ferreira-Neto et al., 2023; Gonzales et al., 2020; Nzomo et al., 2023; Orakcı et al., 2023; Septiyana et al., 2019; Shah & Bhattarai, 2023).

Implication on research

This study was conducted as collaborative research between Indonesia and Thailand. However, it does not rule out the possibility that the results of this study become the basis for didactic design research to develop learning designs that mainstream students' mathematical communication. In addition, research on providing feedback to students that can build students' mathematical communication can also be carried out. However, it does not rule out the possibility that the results of this study become the basis for didactic design research to develop learning designs that mainstream students' mathematical communication.

Limitation

This research was conducted in Thailand as part of a collaborative research program. However, the characteristics of the predominantly Malay students (conducted in southern Thailand) are comparable to schools in Malaysia, Indonesia, and Brunei Darussalam. However, the limitations of the collaborative partners meant that the research subject could not be pluralized across all ethnicities of students.

The limitations of the study include the different languages used, different scripts, and students' lack of ability to use English as a universal language. This affected the data collection process, especially in terms of tests and interviews. Nonetheless, these limitations were overcome by adapting the tests to the Thai script and communicating with the students in a language they understood.

CONCLUSION

Based on the analysis, students with high communication ability (S1) scored 94 and tended to focus less on the written aspect, especially in presenting what is known and asked in the narrative problem. Low-ability students (S3) with a score of 72 showed similar errors to S1 and S2 and appeared to have difficulty understanding the concept of fraction calculation operations. Recommendations include an emphasis on the written aspect, improving concept understanding, and providing school facilities to support mathematics learning.

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