Male vs female, who is better? Students' written mathematical communication skills

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Introduction

Communication skills are one of the essential skills in this globalization era. Therefore, students must master it to face various challenges and changes in the 21st century (Chiruguru, 2020). Given the importance of communication skills in the 21st century for students, the skill must be integrated in teaching and learning process, it is including mathematics. Since students are challenged to think and reason mathematically in math class, the communication skills can be an essential element that can help them to express the their mathematical thinking orally or in writing (NCTM, 2000). In this research, the communication skills in mathematics learning then called mathematical communication skills.

Mathematical communication skills are understanding, interpreting, expressing, responding to, and using mathematical facts, such as terms and symbols to present mathematical ideas orally and in writing (Disasmitowati & Utami, 2017; Rohid et al., 2019). In addition, mathematical communication is the transmission of meaning via spoken, written, and visual means, such as providing oral or written reasoning or justification of results, expressing mathematical thoughts in writing, using symbols, using visual representation, and using concrete objects (Kusumah et al., 2020). Furthermore, mathematical communication cannot only improve students' communication skills but also play a vital role in improving their mathematical abilities. Mathematical communication skills can assist students in developing their understanding and provide opportunities for them to express their mathematical ideas (Hirschfeld-Cotton, 2008). Furthemore, mathematical communication is vital in mathematics because it allows students for expressing, explaining, describing, and listening to their understanding of mathematics (Paridjo & Waluya, 2017).

When viewed from the perspective of gender differences, research states that there is no significant difference between the mathematical abilities of males and females (Hyde & Mertz, 2009). However, the PISA results (OECD, 2011) show a difference between boys and girls students, boys' mathematical abilities are better than girls. As for communication skills, females are superior to males (Adani & Cepanec, 2019). Other studies have also shown that females have better skills in using productive vocabulary and constructing words than males (Eriksson et al., 2012). These studies certainly support the research findings, which state that female students' mathematical communication skills are more prominent than male students (Aliyah et al., 2020; Amni, 2021; Hayati et al., 2020). However, this research on mathematical communication was carried out qualitatively, so the results obtained cannot be used as a generalization. There may be a difference, but not significantly. Based on that information, it is still necessary to confirm the differences between male and female students in terms of mathematical communication; the two are significantly different or not.

Generally, testing of students' mathematical skills is usually carried out in writing form. Therefore, students must have excellent mathematical communication skills for expressing their

ideas, primarily through writing. However, previous studies showed that students' mathematical communication skills in writing are low and need to be improved (Chasanah et al., 2020). Other research showed that students' mathematical communication skills in writing are lower than orally (Maulyda et al., 2020). Considering that students' written mathematical communication skills are still low, it is necessary to carry out further analysis to identify the mathematical communication indicators in which students still experience difficulties and the forms of these difficulties. So, this research will only focus on written mathematical communication skills.

This study aims to determine whether there is a significant difference between male and female students' written mathematical communication skills and to identify the difficulties experienced by them in communicating their mathematical ideas in writing. The findings can later can help teachers in determining suitable strategies for facilitating students' mathematical communication skills. So that teachers can realize differentiated mathematics learning for all students. Then, it will support the principle of mathematical equity in mathematics at school by providing appropriate learning situations to promote access and achievement for all students and eliminate disparate and socially inequitable outcomes in mathematics education (Gutstein et al., 2005; NCTM, 2000).

Methods

Research Design

This research is mixed-method research with a sequential explanatory research design. First, quantitative data will be collected and analyzed, followed by qualitative data analysis to help explain and elaborate on the quantitative results obtained in the first stage (Ivankova et al., 2006). Quantitative methods are used to determine whether there are significant differences between students' mathematical communication skills when viewed from gender. The qualitative method was used to carry out a descriptive analysis of the answers of students to determine their difficulties in written mathematical communication.

Participants

The subjects in this study were 28 junior high school students in the city of Bandung, Indonesia, for the 2021/2022 academic year. The subjects consisted of 28 students, with 14 male and 14 female students. Research subjects were taken through a random sampling technique.

Data Collections

The data was obtained through students' written mathematical skills tests. The research instrument used was three mathematics questions on a quadrilateral topic to measure students' written mathematical communication skills. Before the instrument is used, a theoretical justification is carried out by experts. Table 1 shows the indicators of mathematical communication skills for school mathematics that were adapted from the NCTM (2000). The instrument for

measuring students' mathematical communication skills was adapted from the QUASAR General Rubric, Communication subsection (Lane, 1993) and the Maryland Math Communication Rubric (Maryland State Department of Education, 1991). Each indicator will classify each student into five levels of mathematical communication skills. Since this research emphasizes written communication, the only source of data is the students' response on their answer sheets. Therefore, an interview process was not conducted.

Data Analysis

A statistical test was carried out using the comparison test to determine the difference between the written mathematical communication skills of male and female students, in general and for each indicator. The significance level used in this study is 5%. The students' responses to the questions given were analyzed descriptively to depict the differences in the answers of male and female students and the difficulty they faced.

Table 1 Scoring Guidelines and Indicator of Written Mathematical Communication

Indicator Number	Indicator	Scoring Guidelines	Category
1	Organize and consolidate mathematical thinking and communicate it coherently and clearly to peers, teachers and others	QUASAR General Rubric - Communications	Level 1 = Very Low Level 2 = Low Level 3 = Moderate Level 4 = High Level 5 = Very High
2	Analyze and evaluate the mathematical thinking and strategies of others		
3	Using mathematical language to express mathematical ideas precisely	Maryland Math Communication Rubric	

Results

Profile of Students' Mathematical Communication Skills

Figure 1 shows that most students' mathematical communication skills are still at Levels 1 and 2. In addition, no students can reach Level 5 for each indicator. Indicator 2 is indicator with the lowest achievement among students. As seen from Figure 1, almost all students are at Level 1, which is very low. Apart from Indicator 2, one other indicator of sufficient concern is Indicator 3. The highest-level students can achieve on this Indicator is Level 3, which is still in the medium category. As for indicator 1, the skill level of students on this indicator is more varied than the other two indicators.

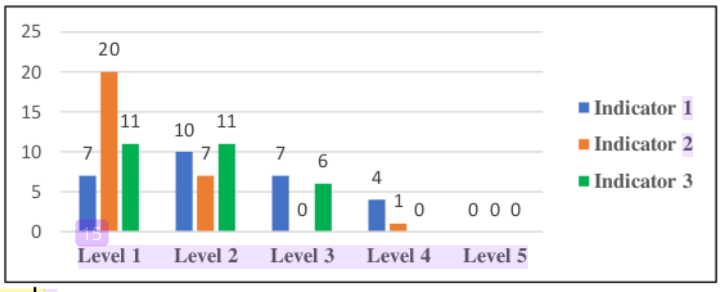


Figure 1 Written Mathematical Communication Skills Level of Students

Comparison of Students' Written Mathematical Communication Level

Table 2 compares the number of male and female students who can reach a certain level for each indicator. In indicator 1, more male students tend to be at level 1, while female students are at level 3. In indicator 2, all female students are at level 1, while more male students are at level 2, and even one male student can reach level 4. In indicator 3, more male students are at level 1, while girls are at level 2. Furthermore, based on Table 2, there may be differences in students' mathematical communication skills in general and for each indicator. So, it is necessary to carry out statistical tests to determine whether these differences are significant. Because the data is ordinal, the Mann-Whitney U test was applied to compare the written mathematical communication skills of male and female students, in general and for each indicator. The analysis results are obtained in Tables 3, 4, and 5.

Table 2 Comparison of Students' Written Mathematical Communication Skill Levels based on gender

	Student Mathematical Communication Skills Level*									
	Level 1		Level 2		Level 3		Level 4		Level 5	
	M	F	M	F	M	F	M	F	M	F
Indicator 1	3	4	10	0	1	6	0	4	0	0
Indicator 2	6	14	7	0	0	0	1	0	0	0
Indicator 3	11	0	2	9	1	5	0	0	0	0

*Description: L = Number of male students at level *i*
P = Number of female students at level *i*
i = 1, 2, 3, 4, 5

Table 3 Differences in Written Mathematical Communication Skills based on gender

	Mean Ranking		Significance Value Mann-Whitney U Test (2-tailed)	Decision
	Male	Female		
Written Mathematical Communication	38.46	46.54	0.103	H0 Accepted

Table 3 shows that, in general, no significant different detected about male and female students' written mathematical communication skills. However, Table 4 shows there is a significant difference for each indicator. Table 5 shows that in the first and third indicators, the female students surpass those of male students. Whereas in the second indicator, male students perform better than female students.

Table 4 Differences in Written Mathematical Communication Skills of each indicator (Two-Tailed Test)

Indicator	Mean Ranking		Significance Value Mann-Whitney U Test (2-tailed)	Conclusion
	Male	Female		
1	11.29	17.71	0.039*	H0 is rejected
2	20.00	9.00	0.000*	H0 is rejected
3	8.96	20.04	0.000*	H0 is rejected

*Significance $p < 0.05$

Table 5 Differences in Written Mathematical Communication Skills of each indicator (One-Tailed Test)

Indicator	Mean Ranking		Significance Value Mann-Whitney U Test (1-tailed)	Conclusion
	Male	Female		
1	11.29	17.71	0.015*	H0 Rejected
2	20.00	9.00	1.000	H0 Accepted
3	8.96	20.04	0.000*	H0 Rejected

*Significance $p < 0.05$

Students' Difficulties in organizing and consolidating mathematical thinking and communicating it coherently and clearly to peers, teachers and other people in writing (Indicator 1)

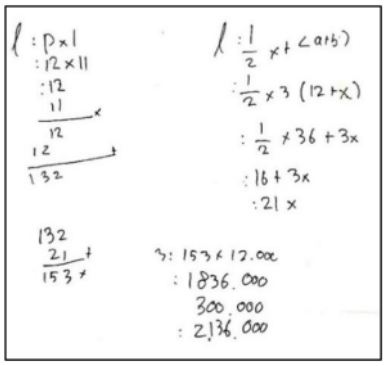


Figure 2 Example of a male student's answer Indicator 1

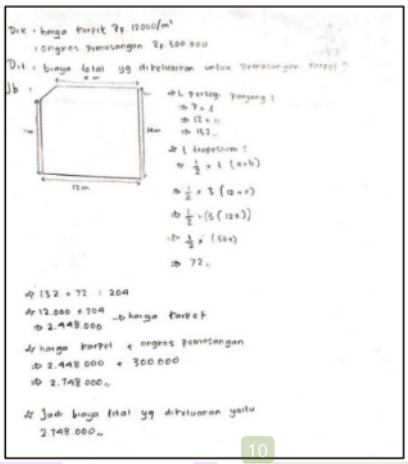
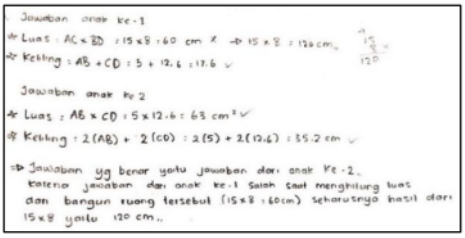


Figure 3 Example of a female student's answer Indicator 1

In Indicator 1, students are asked to determine the total cost needed to install carpet on a floor formed from a combination of two quadrilateral. Figure 2 and Figure 3 show the solving strategies of male and female students, respectively. Figure 2 shows that the answers of male students tend to be more abstract than female students. In the male student's answer, there needed to be an explanation regarding the purpose of carrying out those mathematical operation. Besides that, the step-by-step in solving the problem were complicated for the reader to understand and interpret. From Figure 3, female students can write detailed information clearly so readers can quickly follow the flow of students' thinking. Students also accompanied pictures to help readers understand the initial idea to solve the problem. The descriptions for each step of the solution are also clearly written so that the strategy and flow of solving the problem become easier to understand. However, male and female students still need to improve their understanding in algebraic operations. Since, they often did mistake while calculating algebraic form. For example, students wrote $18 + 3x = 21x$ and $12 + x = 12x$. Apart from errors in operating algebra, students made other mistakes using facts and concepts of quadrilateral.

Students' Difficulties in Analyzing and evaluating other people's mathematical thinking and strategies in writing (Indicator 2)



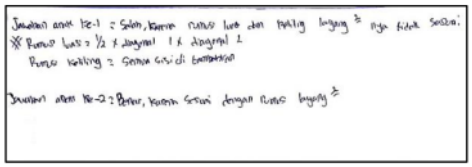


Figure 4 Example of a female student's answer Indicator 2

Figure 5 Example of a male student's answer Indicator 2

In Indicator 2, students are given problem-solving strategies from two children, Child A and Child B, related to the area and circumference of a kite. Students are asked to analyze and evaluate the correctness of the problem-solving strategies of the two children. In this indicator, all female students are at Level 1 because the reasons given do not reflect the solution to the problem. Based on Figure 4, female students only justify the results of number operations without paying attention to the correctness of the area and perimeter concepts of the kites used by the two children. As for the male students, most of them were at Level 2. Their answers indicated that they used the concepts of the area and circumference of kites to evaluate problem-solving strategies (Figure 5). However, some male students made the mistake of justifying the solving strategy from Child B. Even though the Child B used the wrong concept in determining the area of the kite, they tend to consider it as correct answer. So, there is a possibility that male students have not mastered the facts and concepts of kite.

Students' Difficulties in using mathematical language to express mathematical ideas appropriately in writing (Indicator 3)

In indicator 3, students were given two horse stables designs, Designs A and B. They were asked to determine which design a horse breeder could make if the materials they had were limited. This question will examine students' skills in expressing their mathematical ideas using mathematical language. Most of the male students on this indicator are at Level 1 because they only state which design that can be made by a horse breeder without giving reasons for choosing it (Figure 6). At the same time, the majority of female students are at Level 2. Female students have tried to explain why they chose a particular design using mathematical language (Figure 7). Although the mathematical language used is still limited to number symbols. In addition, in the female student's answers there were still errors in using mathematical symbols, she wrote that $15^2 = 15 + 15$ and $5^2 = 5 + 5$.

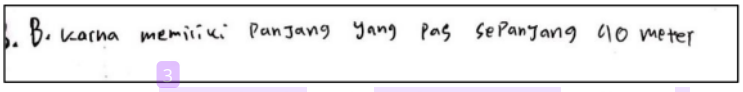


Figure 6 Example of a male student's answer Indicator 3

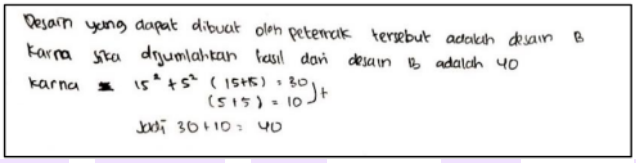


Figure 7 Example of a female student's answer Indicator 3

Discussion

This study aims to identify differences of students' written mathematical communication skills based on gender (male and female). There are three indicators that were used in the study, namely organizing and consolidating mathematical thinking and communicating it coherently and clearly to others; analyzing and evaluating the mathematical thinking and strategies of others; and expressing mathematical ideas precisely using mathematics language. In addition, this study also aims to show the difficulties experienced by students in conveying their mathematical ideas in writing. This research only focuses on written mathematical communication skills so that the analysis results are only based on what is written on the student's answer sheet.

Based on the analysis results, it was found that most of the students' mathematical communication skills in writing were in the deficient category. This result is in line with previous research that students' mathematical communication is still low (Sari et al., 2017) because they still have difficulty expressing their mathematical ideas in writing (Ningtias et al., 2020; Zulkarnain et al., 2021). The lack of writing skills of the student in communication can be occurred because, in written communication, the writer cannot correct or explain the purpose of the information conveyed directly, so written communication requires more effort to be understood by others (Wallace & Roberson, 2008). So, this needs to be a concern for teachers to do not only focus on increasing students' understanding but also on their skills in expressing their mathematical ideas, especially in writing. Since even though students' mathematical skills are good, it is not in line with their mathematical communication skills (Firdiani et al., 2020; Samawati, 2021). Therefore, even though students understand the strategy for solving a problem but have lack ability to express it, of course, it can be a loss for students. In addition, this can cause the results of the learning evaluation to be different from the actual situation.

Several studies have shown that male students surpass female students in mathematical ability (Gabay-Egozi et al., 2022; Keller et al., 2022), while females are superior to males in terms of communication and language skills (Adani & Cepanec, 2019; Al-Saadi, 2020; Denton & West, 2002). Then what about mathematical communication skills? This study shows that, in general, male students are not significantly different from those of female students, viewed from written mathematical communication skills. The result in line with previous research that was conducted by Kamid et al (2020). However, when viewed from each indicator, there are indicators where males are superior to females and vice versa.

Statistically, female students are more superior than male students on the first indicator of written mathematical communication skills. It shows that female students can express and communicate mathematical ideas to others in writing. Analysis of students' answers showed all male and female students tend to experience difficulties in performing algebraic operations, both multiplication and addition operations. Several male and female students also experienced difficulties using the facts and concepts to solve problems in indicator 1. Even so, female students

could present mathematical ideas in a structured manner, accompanied by clear information regarding the steps taken to solve them.

Meanwhile, male students still need help presenting mathematical ideas in a structured manner and tend to be challenging to understand because the flow of the completion steps hard to be followed. Whereas mathematical communication skills do not only focus on problem-solving skills but how to show the idea of solving the problem to others. It is consistent with the study's results, which showed that female students could explain strategies and steps for solving problems in a clear and structured manner, while male students tended to be less structured (Kamid et al., 2020).

In indicator 2, male students are superior to female students. It shows that males' skills in analyzing and evaluating are better than females. However, even though males' skills are higher on this indicator, their skill level is still low, while females are deficient. This indicator has the lowest achievement compared to other indicators because almost all students are at levels 1 and 2. Remembering that analyzing and evaluating skills is one of the higher-order thinking skills (Anderson et al., 2001), this can indicate that students' higher-order thinking skills are still low. It can be used as evaluation for teachers so that they do not only focus on giving questions or assignments that only focus on memorization and application but also provide assignments or questions that can stimulate students' higher-order thinking skills.

Based on the results of the analysis of student answers, on indicator two, female students tend to have difficulty understanding and interpreting the information presented in the questions, so they all only focus on the final answer without checking the truth of the facts and concepts presented in the questions. On the question of Indicator 2, the researcher wrote that the formula for the area of a kite is the multiplication of the two sides of the kite. However, none of the females focused on these mistakes. So, this can be an indication that female students do not understand the facts and concepts of kite construction. On this indicator, male students still experience difficulties using kite facts and concepts in solving problems. It can be seen from their inconsistency in justifying the two strategies presented in the questions. For example, they can justify that Child A's strategy is wrong because Child A uses the wrong concept in determining the area of a kite. Meanwhile, they justify Child B's strategy is correct in determining the area of the kite, even though Child B also made the same mistake as Child A. Even so, male students have demonstrated the use of critical information to solve the problem. However, that information is still lacking to be able to solve all problems precisely.

Indicator 3 also shows that female students' written mathematical communication skills are better than male students. It shows that female students are more proficient in using mathematical language to convey their problem-solving strategies. However, the highest level that students can achieve on this indicator is only at level 3; they can use mathematical languages, such as symbols or terms, but their use is still less accurate and less effective. Teachers should always pay attention to the skills and accuracy of students in using symbols or mathematical terms, remembering that

each symbol and term has its meaning. From the analysis of student answers, on Indicator 3, male students tend not to give reasons for their answer.

In comparison, female students have shown an effort to explain their reasons. However, the use of mathematical language still needs to be improved, and there are still errors in using some symbols. The ineffectiveness of students' use of mathematical language in expressing their ideas can also be seen in their answers to Indicators 1 and 2. Students tend to write certain mathematical symbols without writing down the meaning of the use of those symbols, even though this is very important so that other people can understand their ideas in solving problems (Maryland State Department of Education, 1991).

Therefore, in general, male and female students tend to have difficulties in applying facts and concepts in solving problems, difficulties in using mathematical language, and difficulties in performing algebraic operations. The previous research also revealed that most students needed to improve while doing algebraic form calculations, interpreting the sentence about the presented questions, and understanding the concept that should be used to solve the problem (Nurjanah et al., 2019). Another research also showed that students still have difficulty expressing their mathematical ideas through symbols or mathematical notation (Azizah et al., 2020; Islami & Priatna, 2021). It also becomes evaluation for teachers to improve student understanding about facts and concepts on a particular mathematical topic. In addition, the teacher needs to review algebraic operations topic, since that is fundamental in solving mathematical problems.

Conclusion

This study shows that, in general, the written mathematical communication skills of male and female students are not significantly different. It is in contrast when viewed from each indicator, the difference is significant between the two. In Indicators 1 and 3, female students can perform better than male, but in indicator 2 male is more superior than female.

The challenge for female students in Indicator 1 needs help to apply the facts and concepts of quadrilateral to solve problems and difficulties in operating algebraic forms. The difficulties experienced by male students in indicator 1 are the same as those of female students, but they also experience difficulties in expressing mathematical ideas in a structured manner. In indicator 2, the difficulties experienced by male students are difficulties using facts and concepts related to quadrilateral. In contrast, female students have difficulty understanding and interpreting information and using facts and concepts in solving problems. In indicator 3, the both male and female students have difficulty in using mathematical symbols to express ideas. Thus, male and female students tend to have difficulties in applying facts and concepts to solve problems, using mathematical language, and performing algebraic operations.

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Missing "," You may need to place a comma after this word.

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PAGE 8

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Proofread This part of the sentence contains a grammatical error or misspelled word that makes your meaning unclear.

Missing "," You may need to place a comma after this word.

Frag. This sentence may be a fragment or may have incorrect punctuation. Proofread the sentence to be sure that it has correct punctuation and that it has an independent clause with a complete subject and predicate.

P/V You have used the passive voice in this sentence. Depending upon what you wish to emphasize in the sentence, you may want to revise it using the active voice.

Article Error You may need to remove this article.

PAGE 9

Missing "," You may need to place a comma after this word.

Possessive This word may be a plural noun and may not need an apostrophe.

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Prep. You may be using the wrong preposition.

Missing "," You may need to place a comma after this word.

Article Error You may need to use an article before this word.

Article Error You may need to remove this article.