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Mathematical communication of preservice mathematics teachers in solving gender-biased higher-order thinking skills problems

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ABSTRACT

Mathematical communication is a crucial 21st-century skill related to achievement and other skills. This study aims to analyze the differences in mathematical communication abilities and describe the difficulties male preservice teachers (MPT) and female preservice teachers (FPT) face in solving gender-biased Higher-Order Thinking Skills (HOTS) problems. This research employs a sequential explanatory mixed-methods design. The respondents, selected through purposive sampling, consisted of 4 MPTs and 10 FPTs. Data on mathematical communication abilities were obtained through a gender-biased HOTS problem-solving test. The respondents' difficulties in solving the problems were gathered through interviews. The results indicate differences between MPT and FPT mathematical communication skills using symbols and mathematical notation in solving problems. Student's difficulties in solving gender-biased HOTS problems are unfamiliarity and disinterest in the context. This study implies that education should emphasize contextual understanding and utilize gender-neutral problems to enhance mathematical communication skills.

Komunikasi matematis calon guru matematika dalam memecahkan permasalahan bias gender berbasis kemampuan berpikir tingkat tinggi

Kata Kunci:

Masalah bias gender
Kemampuan berpikir tingkat tinggi
HOTS
Komunikasi matematis
Calon guru matematika

ABSTRAK

Komunikasi matematis merupakan keterampilan penting abad ke-21 yang berkaitan langsung dengan prestasi dan keterampilan lainnya. Penelitian ini bertujuan untuk menganalisis perbedaan kemampuan komunikasi matematis dan mendeskripsikan kesulitan calon guru matematika laki-laki (MPT) dan perempuan (FPT) dalam menyelesaikan permasalahan berbasis *Higher Order Thinking Skills* (HOTS) yang bias gender. Penelitian ini menggunakan desain metode campuran sekuensial eksplanatori. Jumlah responden yang diperoleh secara *purposive sampling* adalah 4 MPT dan 10 FPT. Data kemampuan komunikasi matematis diperoleh melalui tes pemecahan masalah berbasis HOTS yang bias gender. Kesulitan responden dalam menyelesaikan masalah diperoleh melalui wawancara. Hasil penelitian menunjukkan adanya perbedaan keterampilan komunikasi matematis antara MPT dan FPT dengan menggunakan simbol dan notasi matematika dalam menyelesaikan soal. Kesulitan siswa dalam menyelesaikan soal HOTS yang bias gender adalah kurangnya pemahaman dan ketidakpedulian terhadap konteks. Penelitian ini memberikan implikasi kepada pendidikan untuk menekankan pemahaman kontekstual dan memanfaatkan masalah yang netral gender untuk meningkatkan keterampilan komunikasi matematika.

1. INTRODUCTION

Mathematics is known as a language of symbols, whereas learning mathematics is an activity or social activity between students, teachers, and their learning environment [1]. Hence, the activity of mathematics learning in school should feature communication skills related to proof, reasoning, problem-solving, relationships, and representation [2]. The importance of communication skills in mathematics learning is proven by research that concluded mathematical communication skills affect learning achievement, self-efficacy, proofing skills, and mathematics resilience [3]-[8].

Mathematical communication for preservice mathematics teachers is related to four teacher competencies: social, professional, pedagogical, and personality. Professional competence is related to the mastery of scientific structures, concepts, materials, and mindsets that can support teaching each subject. This competency is described in mathematics learning as the ability to use relationships between numbers, functions and patterns, mathematical models and mathematical logic [9]. It's closely related to mathematical communication skills, which are defined as the ability to express mathematical ideas orally, visually, and in writing; the ability to understand, evaluate, and interpret mathematical ideas visually and orally; the ability to use mathematical notation, terms, structures of other mathematical ideas; and the ability to connect mathematical models [2]. To assess and develop mathematical communication skills, tasks with various solution methods provide opportunities to interpret, justify, conjecture, explain, and investigate, and can be represented in many ways [2], [10].

Besides mathematical communication skills, other skills that preservice mathematics teachers must possess are higher-order thinking skills, described as forms of change in the thinking models [11], [12]. Higher-order thinking skills (HOTS) are interpreted as skills included in the cognitive abilities of analyzing (C4), evaluating (C5), and creating (C6), which are measured using non-routine problems related to the real world, requiring students to conduct experiments, and developing the ability to give reasons through various forms of multiple-choice question, short answers, essays, performance tests, and explanation test [13]-[17]. Teachers must have mastered HOTS tasks before teaching HOTS material to the students. Accordingly, mathematical communication skills and HOTS are critical for preservice mathematics teachers to support other abilities.

In addition to the required skills that must be possessed by preservice mathematics teachers, a factor that needs to be considered in mathematics learning is students' gender equity [18]. Male and female students have different interests and needs in learning, such as learning style and learning context, which can affect their achievement [19], [20]. Many mathematics HOTS problems, such as the "Idol Futsal Tournament", contain a gender-biased context. The tournament of 4 teams consists of BTS, TXT, ECO, and NCT. Each team played two times with the result standings shown in Table 1. The questions are: (1) What was the score of the match between Team BTS and Team NCT, (2) Could BTS play win with TXT, EXO, and NCT? Please explain. (3) Make a match chart regarding the information in the result standings.

Students' answers to the questions regarding the futsal tournament context can be influenced by their knowledge of the rules in futsal tournaments, which male students are more familiar with than female students. Hence, the implementation of assessment using the test instrument in Table 1 differentiates the performance of certain groups to show their performance/ability to get better or get worse [21]-[23]. However, it does not rule out the possibility that female students can solve these problems using their good analytical skills. Fennema said that gender differences affect complex mathematical skills, self-confidence in mathematics, and career choices that involve mathematics [24].

Table 1. Idol Futsal Tournament Standings

Team	Play	Win	Draw	Lose	Goals For-Against
BTS	2	2	0	0	5-1
TXT	2	1	1	0	1-0
ECO	2	0	1	1	0-1
NCT	2	0	0	2	1-5

Previous studies found inconsistent results of students' differences in the ability to solve HOTS problems based on gender [25]-[28]. Meanwhile, previous studies regarding mathematical communication skills in solving HOTS problems based on students' gender concluded that male students' mathematical communication scores were lower than female students [29]-[32]. Male students could not logically represent problems through images, symbols, and analogies [33]. On the contrary, the ability to make an abstraction and use various points of view to solve problems for male students is better than for female students [34]. Another research found that the mathematical communication skills of female and male students are not significantly different with the application of the problem-solving learning model [35]. However, the previous research did not mention the mathematics communication skills of male and female students to solve HOTS problems based on specific gender contexts, male or female context. These previous studies only view the differences in scores obtained between female and male students. The context problems used in the instrument were not categorized based on gender.

This study aims to analyze the differences in mathematical communication skills and describe the difficulties faced by male (MPT) and female (FPT) prospective mathematics teachers in solving gender-biased HOTS-based problems. Contextual insight related to gender is essential for preservice mathematics teachers to give students experience in solving real-life context problems [36], [37]. There is evidence in this life that male experts in female areas and vice versa, such as male ob-gyn specialist doctors or female football analysts and commentators. According to the previous research, an in-depth analysis of mathematical communication skills at the higher education level based on students' gender is needed. Preservice mathematics teachers should have broader context knowledge to teach mathematics effectively in the classroom with different gender and background students [38]. The context should be able to make the concept or sub-concept visible to be learned [39]. This is in line with the differentiated learning implementation in the national curriculum which facilitated student diversity in gender, interest, talent, and background [40]. Therefore, this research will analyze the mathematical communication skills of preservice mathematics teachers in solving gender-biased HOTS problems based on their gender and different genders. In addition, this research will describe the difficulties faced by male and female preservice mathematics teachers in solving gender-biased HOTS problems.

Contribution to the literature
This study contributed to:
- Filling the gap in the mathematical communication skills of preservice mathematics teachers in solving contextual problems with HOTS characteristics and gender bias.
- This study's findings gave insight into how preservice mathematics teachers' understanding and interest in gender-biased problems impacted their problem-solving process.
- This study suggested that the context used in the test might be gender-biased but should be given clear information and illustration.

2. METHOD

The explanatory sequential mixed methods design, which consists of quantitative analysis followed by qualitative analysis to explain the results of the quantitative analysis, was used to analyze respondents' mathematical communication skills in solving gender-biased HOTS problems [41]-[43]. The research flow process is defined in Figure 1.

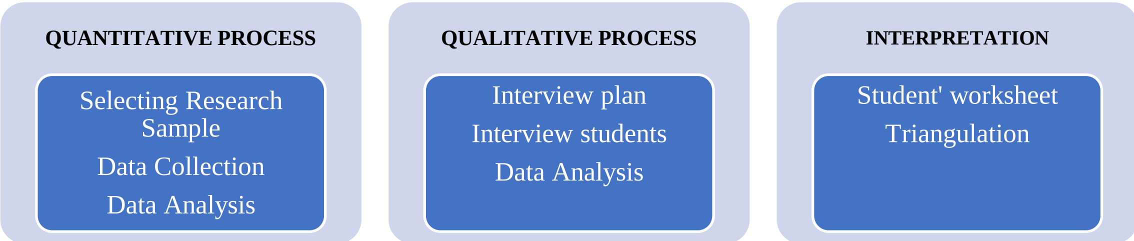


Figure 1. Research Flowchart

The research subjects were 7th-semester students of a mathematics study program grouped by gender with details of 11 MPT and 77 female preservice mathematics teachers (FPT). The research sample was selected using purposive sampling based on the Selecta Capita (*Kapita Selekta*) of Junior High School Mathematics course grades. The grades in the course were converted into scores with a range of 56-100 according to the Institute's 2020 academic guidelines. As a result, 4 MPTs (codes L1MS, L2MF, L3AA, L4AR) and 10 FPTs (codes P1YA, P2NF, P3FW, P4KL, P5RA, P6MD, P7JA, P8AH, P9SQ, P10DA) with the highest scores were selected as the research samples. The preservice mathematics teacher with the highest scores results indicated that they have good knowledge of the content and context of mathematics for junior high school.

The quantitative data of the respondents' mathematical communication skills collection used essay test instrument-based gender-biased HOTS problems consisting of 5 items. The mathematics content used in the instrument includes numbers, geometry, data analysis and probability content. The contexts used in the instrument are the *Congklak* game, Golden Ratio Makeup, Choosing Tire Type, Motor Racing, and Football Tournaments. The indicator of mathematical communication skills consists of the ability to make mathematical models according to the problem (indicator 1), the ability to use symbols and correct mathematical notation in the problem-solving process (indicator 2), and the ability to interpret and evaluate mathematical ideas made orally or in writing (indicator 3) which adapted [2], [10], [44]-[46]. In addition, the qualitative data collection used interviews and documentation of respondents' worksheets.

The research data were analyzed with statistical descriptive analysis and inferential analysis. The statistical descriptive analysis was conducted on the mathematical communication scores of MPT and FPT in solving gender-biased HOTS problems which consist of mean, standard deviation, maximum score, and minimum score. The maximum score for mathematical communication is 45, whilst the minimum score is 0. The respondents' scores were categorized into e, high, moderate, low, and poor mathematical communication skills [47]. Due to the small number of samples and non-normal data, the Wilcoxon Rank Sum statistical test was used to analyze differences in scores in overall mathematical communication skills and each indicator of mathematical communication skills between MPT and FPT [48]. To find out the difficulties of MPT and FPT, triangulation techniques were used in the respondents' interview transcripts and students' worksheet documents.

3. RESULTS AND DISCUSSION

The test results of 4 MPTs and 10 FPTs on gender-biased HOTS problems, which have been conducted, are shown in Table 2.

Table 2. Description of Preservice Mathematics Teachers' Mathematical Communication Skills

Description	MPT	FPT
Mean	21	15.3
Standard Deviation	8.76	5.76
Maximum	33	23
Minimum	12	5

Table 2 shows that the average of MPT mathematical communication skills is higher than FPT's. The results of this research differ from [31], where females', where females' mathematical communication skills are better than males'. On the other hand, the standard deviation of FPT's mathematical communication skills is better than MPT's, as the FPT scores are more evenly distributed than MPT's. Next, the scores of mathematical communication skills are grouped according to the context of the problems used.

Table 3. Mathematical Communication Skills in the Context of Gender-Biased HOTS Problems

	Female Context Problem	Male Context Problem
MPT	10	11
FPT	8.1	7.2

According to Table 3, MPTs have higher scores in mathematical communication skills than FPTs in all contexts. In addition, in the context of the problem used, MPT obtained better scores of mathematical communication skills in the context of male problems (11) than in the context of female problems (10). In contrast, FPTs' scores of mathematical communication skills are better in the context of female problems (8.1) than in the context of male problems (7.2). It can be concluded that the mathematical communication skills of MPT and FPT obtained better results according to the context related to their gender. In the next stage, the mathematical communication scores of MPT and FPT were grouped according to the mathematical communication skills indicators.

Table 4. Mathematical Communication Skills Percentage on each Indicator

Mathematical Communication Skills Indicator	MPT (%)	FPT (%)
Indicator 1	61.67	57.33
Indicator 2	40	23.33
Indicator 3	38.33	21.33

In each mathematical communication skills indicator, MPT is higher than FPT (Table 4). Both MPT and FPT obtained the highest percentage in indicator 1, namely the ability to make mathematical models according to the problem. Meanwhile, the lowest percentage was in indicator 3: the ability to interpret and evaluate mathematical ideas made orally or in writing. The highest margin of differences in mathematical communication skills between MPT and FPT was in indicator 2. The MPT uses mathematics symbols and notation better than FPT, as stated by Kamid et al. [49]. Furthermore, it is categorized below to analyze the achievement of each student's mathematical communication skills.

Table 5. Categorization of Mathematical Communication Skills

Scores	Criteria	Frequency	Percentage (%)	MPT	FPT
$29 \leq X \leq 34$	Very high	1	7.14	1	0
$23 \leq X \leq 28$	High	1	7.14	0	1
$17 \leq X \leq 22$	Moderate	6	42.86	2	4
$11 \leq X \leq 16$	Low	4	28.57	1	3
$5 \leq X \leq 10$	Very low	2	14.29	0	2

The percentage of mathematical communication skills in solving gender-biased HOTS problems is mainly in the moderate criteria (Table 5). There is 1 MPT only, which achieved very high criteria. Meanwhile, 2 FPTs are categorized into shallow criteria. The lack of maximizing students' mathematical communication skills in solving gender-biased HOTS problems can be influenced by the lack of habituation activities in learning. Educators have not carried out assessments that focus on 21^{st}-century skills that at least contain competencies in the process of solving mathematical problems and competencies related to tools and language as well as the application of HOTS abilities even though educators understand the meaning, strategies, and use of HOTS in learning [50], [51].

In the third indicator, the ability to interpret and evaluate mathematical ideas orally or in writing, the achievement of mathematical communication of MPT and FPT obtained the lowest score. This supports the study that females and males obtained the lowest scores on indicators that measured the ability to provide rational reasons and conclusions and analytical skills [52], [53]. The low ability of preservice mathematics teachers to interpret and evaluate mathematical ideas is supported by qualitative data in this research, where they lack mathematical and logical thinking skills in solving problems. Mathematical and logical thinking skills significantly correlate with mathematical communication skills as they affect the ability to analyze problems, apply formulas or patterns, and communicate mathematical problem-solving [54], [55].

Moreover, the results also showed that MPT and FPT obtained the highest achievement percentage in making mathematical models of the problem. This aligns with the finding that the ability to explain ideas, situations, and mathematical relationships orally or in writing with natural objects, graphs, and drawings obtained the highest score [56]. The ability to make mathematical models indicated sophisticated mathematical thinking, including making abstractions and connections as well as using mathematical tools and language [57]. It can support the preservice mathematics teachers in teaching the mathematization process from concrete to abstract.

3.1 Mathematical Communication Skills Differences of MPT and FPT in Solving Gender-Biased HOTS Problems

The total rank of MPT and FPT mathematical communication skills in solving gender-biased HOTS problems is as follows.

Table 6. Total MPT and FPT rank

MPT	Rank	FPT	Rank
L1	14	P1	13
L2	10.5	P2	12

L3	8.5	P3	10.5
L4	4	P4	8.5
		P5	7
		P6	5.5
		P7	5.5
		P8	3
		P9	2
		P10	1

The calculation of the total rank of mathematical communication skills in Table 6 obtained the Wilcoxon Rank Sum Statistic value of 13, which is higher than the Wilcoxon Rank Sum Table of 5. There is no significant difference in the ranking of MPT and FPT mathematical communication skills in solving gender-biased HOTS problems despite MPT obtaining a better score than FPT, $z = 0.99$, $p = .374$. This finding is similar to the study in that there are no differences in mathematical communication skills between male and female students [58]. Siregar et al. stated that gender did not significantly affect mathematical communication skills among students with equal achievement [59]. Following this result, an analysis was also conducted on each indicator of mathematical communication skills. On the first mathematical communication skills indicator, the ability to make mathematical models according to the problem, the following results were obtained in Table 7.

Table 7. MPT and FPT Ranks on Indicator 1

MPT	Rank	FPT	Rank
L1	14	P1	13
L2	8.5	P2	11.5
L3	8.5	P3	11.5
L4	1.5	P4	8.5
		P5	8.5
		P6	5.5
		P7	5.5
		P8	3.5
		P9	3.5
		P10	1.5

The calculation of the total rank of mathematical communication skills in Table 7 obtained the Wilcoxon Rank Sum Statistic value of 17.5, more significant than the Wilcoxon Rank Sum table of 5. This means that there is no significant difference in ranking between MPT and FPT mathematical communication in solving gender-biased HOTS problems based on the score on the indicator of the ability to make mathematical models of the problem, $z = 0.36$, $p = .733$. Both male and female students can write down the mathematical model of problems [60]. Meanwhile, the results are as follows on the second mathematical communication skills indicator, the ability of MPT and FPT to use symbols and correct mathematical notation in the problem-solving process.

Table 8. MPT and FPT rank on indicator 2

MPT	Rank	FPT	Rank
L1	14	P1	11.5
L2	11.5	P2	11.5
L3	11.5	P3	8.5
L4	8.5	P4	4
		P5	4
		P6	4
		P7	4

		P8	4
		P9	4
		P10	4

The calculation of the total rank of mathematical communication skills in Table 8 obtained the Wilcoxon Rank Sum Statistic value of 4.5, smaller than the Wilcoxon Rank Sum table of 5. It can be concluded that there is a significant difference in ranking between MPT and FPT mathematical communication in solving gender-biased HOTS problems based on students' ability to use symbols and correct mathematical notation in the problem-solving process as MPT attained better score than FPT, z = 2.37, p = .024. It means that MPT can better use symbols and correct mathematical notation in solving problems. This result is from the study that in international level Olympics that use HOTS questions, the percentage of women's participation and results are lower than that of men [61]. The differences between MPT and FPT in using symbols might be due to the different cognitive styles between males and females, where males are better at analytic and imagery learning than females [62]. Lastly, on indicator 3 of mathematical communication skills, namely the ability of MPT and FPT to interpret and evaluate mathematical ideas, the results were obtained in Table 9.

Table 9. MPT and FPT Ranks on Indicator 3

MPT	Rank	FPT	Rank
L1	14	P1	13
L2	9.5	P2	12
L3	9.5	P3	11
L4	6	P4	6
		P5	6
		P6	6
		P7	6
		P8	2.5
		P9	2.5
		P10	1

Calculating the total rank of mathematical communication skills in Table 9 obtained the Wilcoxon Rank Sum Statistic value of 11 more significant than the Wilcoxon Rank Sum table of 5. In other words, there is no difference in ranking between MPT and FPT mathematical communication in solving gender-biased HOTS problems on the ability to interpret and evaluate mathematical ideas, z = 1.31, p = .240. Male and female students can interpret and evaluate the idea although it is different in constructing the mathematical model [58].

3.2 MPT and FPT Difficulties in Solving Gender-Biased HOTS Problems

There are only 2 out of 14 preservice mathematics teachers who obtain high and very high criteria. According to the interview, preservice mathematics teachers experienced difficulties in solving the problems, especially on the problem with the *Congklak* game and Football Tournaments context. In the interview, P1YA said:

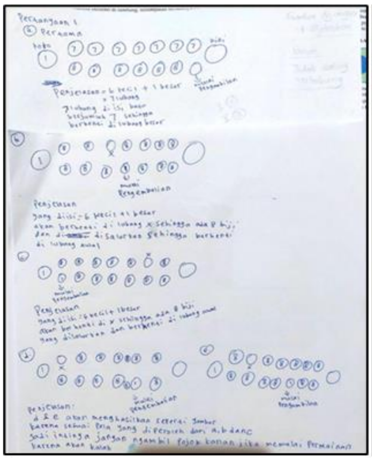
"*I have never played Dakon directly, so it is difficult to understand the illustration of the problem.*"

P1YA considered that the context of the *Dakon (Congklak)* game was unfamiliar, so it impacted their understanding of the problem stimulus given. The interview results were checked for accuracy through the document of the P1YA's answer sheet on problem number 1, which used the context of the *Congklak* game; the P1YA did not provide the answer. It can be concluded that familiarity with the context problem affects students' problem-solving performance. Familiarity and interest in the context affect students' mathematical thinking skills, one of which is the ability to make appropriate mathematical models [63]. The use of familiar and exciting context problems can help educators explain concepts that are difficult to understand, increase positive attitudes and student achievement [64], [65], and minimize gender differences [66].

Leder and Forgasz proposed the idea of mathematics as a neutral domain [67]. This perception requires educators to view mathematics not only for females or males, so in learning, educators must also use a neutral context that does not favour the interests of males or females. Moreover, the results of interviews with P6MD, L2MF, and P4KL who experienced unfamiliarity with the *Congklak* context problem are as follows.

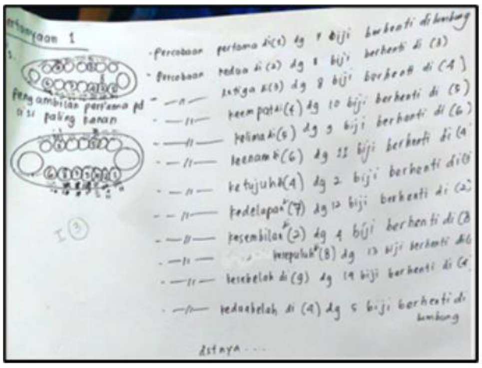
"*The difficulty was that I had to work by practising the Congklak game individually. It took quite a long time, then the first time I did it, I put the wrong seeds in the opponent's barn. Finally, I had to do it again from the beginning*" (P6MD)."
"*Connecting the problem with the concept of the play takes a lot of time*" (L2MF)."
"*The difficulty in solving this problem is that it takes a lot of time to calculate the possible experiments and adjust the problems given*" (P4KL)."

The interview mentioned that the problem with the context of the *Congklak* requires accuracy, so it takes longer to do. This conclusion is supported by the respondents' answer sheet documents, which show no problems related to understanding the procedures of the *Congklak* game (Figures 2 and 3).



Translate:
a. Start taking from the far right side.
Explanation:
6 small holes + 1 large hole = 7 holes. Then the 7 holes are filled with seeds so that they stop at the large hole.
b. Start taking at the very center hole
Explanation:
6 small holes + 1 large hole = 7 holes. Then it will stop at the hole marked X and contain 8 seeds
c. Start taking at the leftmost hole.
Explanation:
6 small holes + 1 large hole = 7 holes. Then it will stop at the hole marked X and contain 8 seeds.
d and e will produce according to the picture because they match the patterns in a, b, and c.
In conclusion, don't take the far right side so you don't lose.

Figure 2. LM2F's Answer in the *Congklak* Game Context Problem



Translate:
- First try on hole (1) with 7 seeds stopping in the barn
- Second attempt at hole (2) with 8 seeds stopping at hole (3)
- Third try on hole (3) with 8 seeds stopping on hole (4)
- Fourth attempt on hole (4) with 10 seeds stopping on hole (5)
- Fifth attempt on hole (5) with 9 seeds stopping on hole (6)
- Sixth attempt on hole (6) with 11 seeds stopping on hole (4)
- Seventh try on hole (4) with 2 seeds stopping on hole (7)
- Eighth try on hole (7) with 12 seeds stopping on hole (2)
- Ninth try on hole (2) with 4 seeds stopping on hole (8)
- Tenth attempt on hole (8) with 13 seeds stopping on hole (5)
- Eleventh try on hole (9) with 14 seeds stopping on hole (4)
- Twelfth attempt on hole (4) with 5 seeds stopping in the barn

Figure 3. P6MD's Answer in the *Congklak* Game Context Problem

On the other hand, there are preservice mathematics teachers who are familiar with the context but find it difficult. The interview results regarding difficulties in solving problems with the *Congklak* contexts for P3FW, P5RA, and P10DA are as follows.

"*Basically, I am familiar with a game called Congkak but I am confused about how to play it. Therefore, I cannot answer this problem*" (P3FW)
"*Concerning the way of playing Congklak written in the illustration of the problem, which is different from how I played Congklak as a child (regardless of which way is correct), I had difficulty answering. As I recall, I used to play counterclockwise when another player stopped. To solve problem number 1, I also experienced confusion because when I tried to play Congklak based on the conditions in the problem, the last position was not in the barn*" (P5RA)
"*I was confused about the location of the players' barns in the Congkak game, even though it was explained that the rotation method is clockwise, but I felt confused about determining the barn belonging to player 1 with player 2's barn*." (P10DA)

According to the interview results, it can be seen the students experienced problems in understanding the stimulus of the *Congklak* games, even though it contains a complete explanation of the *Congklak* game with the procedures for playing. Preservice mathematics teachers' lack of understanding of the stimulus of the *Congklak* game resulted in their inability to solve the problem. This can be seen from the answer sheet of P3FW, who did not work on the *Congklak* problems, and the answers of P5RA and P10DA, who could not explain the reasons for their answers (Figure 4 and Figure 5).

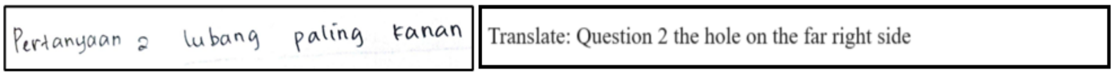


Figure 4. P3FW's Answer in the *Congklak* Game Context Problem

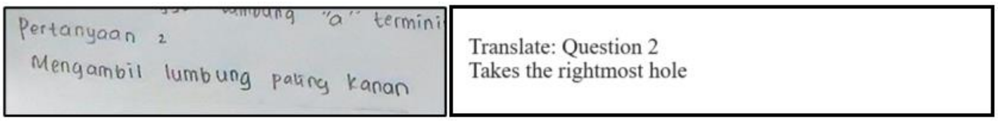


Figure 5. P5RA's Answer in the *Congklak* Game Context Problem

Preservice mathematics teachers' difficulties in solving gender-biased HOTS problems in the *Congklak* game context were also found in interviews with L3AA as follows.

"*The difficulty in solving this problem is the lack of ability to analogize images*."

The interview results were then adjusted to the answers of L3AA in problem number 1 as follows.

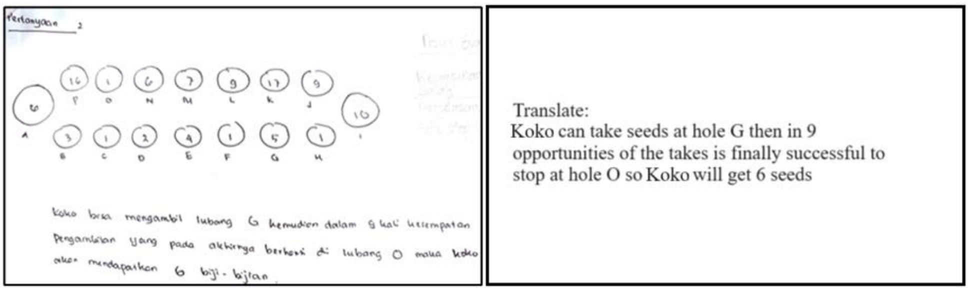


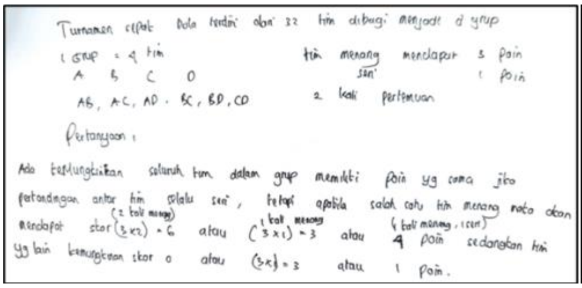
Figure 6. L3AA's Answer in the *Congklak* Game Context Problem

Referring to the results of interviews and answer sheets of L3AA above, the difficulties experienced by L3AA in solving problems of the *Congklak* game context is explaining each possible answer with pictures. This is evidenced in Figure 6; L3AA does not make many possible answers and does not explain step by step, so it cannot determine the most appropriate step so that the barn is filled with the most grains. Based on the results of interviews and respondents' answer sheets on the context of the *Congklak* game problem, it can be concluded that the difficulties experienced by preservice mathematics teachers are related to familiarity with the context of the problem, understanding the context of the problem, skills in making models, diligence, accuracy, and processing time.

Furthermore, in the Football Tournaments context, the first difficulty in solving the problems is related to students' interest in the context presented in the problem. This is based on the results of the P1YA's interview as follows.

"*Difficulty in deciding whether to play 2 rounds of football at once or not, because in general, I don't like football games*."

P1YA's disinterest in the context of the Football Tournaments resulted in her answer.


Turnamen sepak bola terdiri dari 32 tim dibagi menjadi 8 grup
1 grup = 4 tim
A B C D
AB, AC, AD, BC, BD, CD
tim menang mendapat 3 poin
seri 1 poin
2 kali pertemuan
Pertanyaan :
Ada kemungkinan seluruh tim dalam grup memiliki poin yg sama jika pertandingan antar tim selalu seri, tetapi apabila salah satu tim menang maka akan mendapat skor (3×2) = 6 (2 kali menang) atau (3×1) = 3 (1 kali menang) atau 4 poin (1 kali menang, 1 seri) sedangkan tim yg lain kemungkinan skor 0 atau (3×) = 3 atau 1 poin.

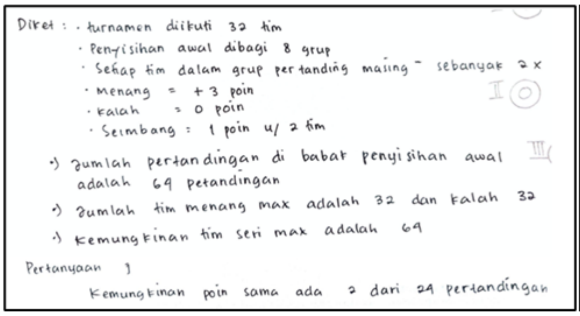
Translate:
There is a possibility that all teams in a group have the same points if the matches between the teams are always a draw. However, if one team wins 2 times it will get a score of (3x2) = 6, if it wins 1 time it will get a score of (3x1) = 3 or 4 points if it wins 1 time and 1 draw. Meanwhile, the other team might get a score of 0 or (3x1) = 3 or 1 point.

Figure 7. P1YA's Answer to the Football Tournament Context Problem

The P1YA's answer is correct: each team will get the same score if all teams play a draw (Figure 7). However, P1YA cannot explain the reason or draw a matching chart in one or more groups. P1YA also miswrites the idea of multiplication. P1YA's answer is supported by the following interview results with P3FW, P8AH, P2NF, P5RA, and L1MS:

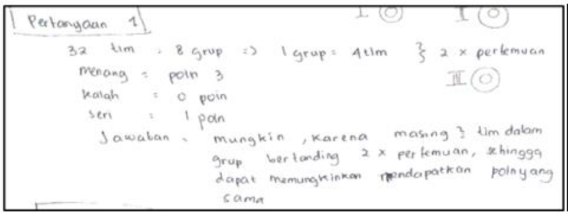
"*I am still confused about the meaning of this problem*" (P3FW)
"*I haven't done this problem yet, because I am still confused in explaining whether all teams will get the same points*" (P8AH)
"*I read this problem then confused after being divided into eight groups. Each team competed against each other for 2 meetings. Now this means 2 meetings against the same or different teams*" (P5RA)
"*The obstacle is difficult to pay attention to the problems, each team in the group competes with each other for two meetings each, so they are hesitant to answer*" (L1MS)

The interview results of P3FW, P8AH, P2RA, P5NF, and L1MS show that they did not understand the rules of Football Tournaments. Hence, they cannot describe the various schemes of that Football Tournament context and the various possibilities to produce the same points for each team. P3FW and P8AH could not solve the problem, whereas P2RA, P5NF, and L1MS tried to solve it but were incorrect. The interview results were matched with their answer document as follows.



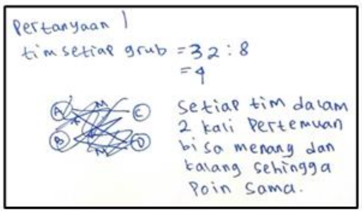
Translate:
-The number of matches in the initial preliminary round is 64 matches
-The maximum number of winning teams is 32 and losing 32
-The maximum probability of a team drawing is 64
-Possible points are equal to 2 out of 24 matches

Figure 8. P2RA's Answer to the Football Tournament Context Problem



Translate:
Maybe because each team in the group competes twice so it is possible to get the same points

Figure 9. P5NF's Answer to the Football Tournament Context Problem



Translate:
Each team can win and lose in 2 meetings so that the points are the same

Figure 10. L1MS's Answer to the Football Tournament Context Problem

The answers of P2RA (Figure 8), P5NF (Figure 9), and L1MS (Figure 10) showed a lack of understanding of the Football Tournament rules even though these rules had been explained in the stimulus. This results in preservice mathematics teachers being unable to determine the various possible points obtained by each team and the game scheme. The difficulties of preservice mathematics teachers in solving biased-gender HOTS problems might be an obstacle in giving an example of a mathematics concept as they often rely on prior knowledge and raw content knowledge to teach [68].

Mathematics learning in the Emancipated (*Merdeka*) Curriculum encourages teachers to design materials with innovative learning strategies and conduct assessments adapting from PISA using contextual problems as stimulus [69]. Teachers should be able to design opportunities for rich conceptual learning for students following the theoretical and pedagogical content knowledge [70]. Teachers with limited contextual literacy will have difficulty teaching as high school students' mathematical context literacy is limited based on their daily lives [71]. High school students preferred context related to their gender and interest [72]. Therefore, to avoid students' difficulties in understanding the context, the problem used in mathematics learning, especially in assessment, should not be gender biased. Thus, it's recommended for preservice mathematics teacher to expand their knowledge of gender-biased context to broaden their insight into teaching mathematics content using gender-neutral context. In constructing problems, it is recommended not to use a gender-biased context or provide clear information and illustrations of the context so that students can show their actual performance. The results of MPT and FPT mathematical communication scores, which are in the moderate criteria, provide opportunities for educators to improve mathematical communication skills, especially the ability to interpret and evaluate ideas in the learning process to support the competence of preservice mathematics teachers. Educators in universities must encourage students to expand their context knowledge related to mathematics content. This research did not provide the ability of preservice mathematics teachers to develop unbiased gender mathematical HOTS problems. Therefore, future research opportunities after this research are regarding the ability of preservice mathematics teachers to develop mathematical problems in a gender-neutral context to measure students' numeracy literacy.

4. CONCLUSION

Based on the results and discussion, the difference in mathematical communication skills in solving gender-biased HOTS problems between MPT and FPT lies in indicator 2, namely the ability to use symbols and correct mathematical notation in the problem-solving process. The overall mathematical communication skills of MPT and FPT in solving gender-biased HOT problems are not significantly different, even though MPT attains better results than FPT. The difficulties experienced by MPT and FPT in solving gender-biased HOTS problems are familiarity and interest (positive attitude) in the context, which often require a long process of understanding, modelling, and calculating. The study implies that educators should promote contextual understanding and utilize gender-neutral problems to enhance mathematical communication skills.

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AUTHOR CONTRIBUTION STATEMENT

ES contributed to the conceptualization, methodology, data collection, and writing of the original manuscript. RR contributed to the design of the instrument, data analysis, layout, and translation of the manuscript.

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