

The Interaction between Mathematical Problem-Solving Skills and Mathematical Communication Skills of Junior High School Students: A Qualitative Approach

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Abstract. Mathematical problem-solving skills (MPSS) and mathematical communication skills (MCS) has a very close relationship. Before solving a problem, students should understand the problem first, processing and presenting their answer, which is a MCS. Different from the previous study, this study reveal the relationship and interaction between students' MPSS and MCS using a qualitative approach. To do this, a case study method is conducted using valid test and interviews. The test consist of three cases: smartphone storage, riddle about number of chickens and the coop, and area of land to be planted with corn. The participants of this study were eighth-grade 18 students from various junior high scholl and region in West Sumatra. Data analysis used is a descriptive analysis of students' test answers and interview results. The results show that there are five of nine interactions between MPSS and MCS: solver, self-solver, sharer, regular, and receiver. Solver is a student with high MPSS and MCS (2 students), self solver is a student with high MPSS but moderate MCS (6 students), sharer is a student with moderate MPSS but high MCS (4 students), regular is a student with moderate MPSS and MCS (3 students), and receiver is a student with low MPSS and MCS (3 students). The results of this study also show that the relationship between MPSS and MCS is very close. Although there are students who have MPSS and MCS that do not match, this is inseparable from the limitations of the research conducted.

Keywords: Assessment; Case Study; Mathematical Communication Skills; Mathematical Problem-Solving Skills

Abstrak. Kemampuan pemecahan masalah matematis (KPM/MPSS) dan kemampuan komunikasi matematis (KKM/MCS) memiliki hubungan yang sangat erat. Sebelum menyelesaikan suatu masalah, peserta didik harus memahami masalah terlebih dahulu, mengolah dan bahkan menyajikan jawabannya nantinya, yaitu berkomunikasi matematis. Berbeda dari penelitian sebelumnya, penelitian ini akan mengungkapkan kembali hubungan dan interaksi antara kemampuan pemecahan masalah dan komunikasi matematis peserta didik dengan menggunakan pendekatan kualitatif. Untuk melakukannya, metode studi kasus digunakan dengan memakai soal tes yang sudah valid dan wawancara. Soal tes terdiri dari tiga kasus, yaitu kasus penyimpanan smartphone, teka-teki banyak ayam dan kandang, dan luas tanah yang akan ditanami jagung. Partisipan penelitian ini adalah 18 orang peserta didik dari kelas 8 di Sumatera Barat. Analisis data yang digunakan adalah analisis deskriptif terhadap jawaban tes peserta didik dan hasil wawancara. Hasil penelitian menunjukkan bahwa terdapat 5 dari 9 kelas atau interaksi antara MPSS dan MCS, yaitu solver, self solver, sharer, regular, dan receiver. Solver merupakan peserta didik dengan MPSS dan MCS tinggi sebanyak 2 orang, self solver merupakan peserta didik dengan MPSS tinggi tetapi MCS sedang (6 orang), sharer merupakan peserta didik dengan MPSS sedang tetapi MCS tinggi (4 orang), regular merupakan peserta didik dengan MPSS dan MCS sedang (3 orang), dan receiver merupakan peserta didik dengan MPSS dan MCS rendah (3 orang). Hasil penelitian ini juga menunjukkan bahwa memang hubungan antara MPSS dan MCS sangatlah erat. Meskipun terdapat peserta didik yang memiliki MPSS dan MCS tidak bersesuaian, hal ini tidak terlepas dari batasan penelitian yang dilakukan.

Kata kunci: Asesmen; Kemampuan Komunikasi Matematis; Kemampuan Pemecahan Masalah Matematis; Studi Kasus



INTRODUCTION

Mathematical problem-solving skills (MPSS) is one of the most important skills to achieve by the students in learning mathematics. With good MPSS, students' can solve daily life problems even the high order thinking skills problems (Aripin et al., 2024; Septriasyah et al., 2022). Furthermore, National Council of Teachers of Mathematics (NCTM) served the problem solving to be the first mathematical skill in every grades and encourages the use of problem solving as a central part of mathematics instruction (NCTM, 2000). Problem solving is also one of the mathematics learning objectives in Indonesia curriculum (Rohmah et al., 2023). In mathematical literacy, which is an international standard for education nowadays, problem solving is also taking part as an aspect or factors in solving real-world problems (Le Roux & Sebolai, 2017; OECD, 2023). Moreover, a lot of people recognize that problem solving skill in general or MPSS especially is important and usable in daily life and students' future work (Cote, 2023; Prabawanto et al., 2023).

Simple definition of problem solving is how the students solve a problem, including contextual or daily life problems. Problem solving is the integral part of all mathematics learning, where the students need to draw their own knowledge, and also some of the students will find a new mathematical understanding to solve the problems (Bal & Artut, 2022; Prasad, 2021). The MPSS is how the students build new mathematical knowledge, solve problems that arise in mathematics and in other contexts, apply and adapt a variety of appropriate strategies, monitor and reflect on the process (NCTM, 2000). PISA defines three categories of processes in solving problems: formulating the problems; employing mathematical concepts, facts, procedures and reasoning; and interpreting, applying and evaluating the solution (OECD, 2023). In conclusion to, in solving a problem, start from understanding the problem, students need to have other mathematical skills, especially mathematical communication skills (MCS).

In solving a problem, students' MCS is included in how the students understand, process, and present their answer in their paper or even in front of the class. MPSS and MCS has a very close relation, even the teacher will also tend to ask the students to present their answer in front of the class to support the meaningful learning process (Le et al., 2018; Rusyda et al., 2020). Nevertheless, some students can solve the problems but can not present their answer (Groves & Robinson, 2024; Waswa & Al-Kassab, 2023). MCS is the way of students presenting their idea, oral or verbal, which is very important (Putri & Musdi, 2020; Sari & Yuberta, 2022). Students' MCS is indicated with how are they organize and consolidate their mathematical thinking; communicate coherently and clearly to peers; analyze and evaluate others presentation; use the language of mathematics precisely (Marniati et al., 2021; Tupamahu et al., 2023). Once a solution has been found, the problem solver may need to present the solution, and perhaps an explanation or justification, to others (Nasrullah et al., 2023; OECD, 2023).

The MPSS and MCS is cannot be divided each other. This is supported by previous studies that found a positive and significant relationship between problem solving and communication (Junsay, 2016; Laia & Surven, 2023). Furthermore, Rohid et al. (2019) investigated students MCS in solving a problems where they found that only 1 of 3 students that has good MCS. Puspa et al. (2019) found that in solving problems, each students tend to have different style. At the end, the MCS of the students is very important in solving problems including contextual or even technologycal problems (Martins & Martinho, 2021; Neria & Amit, 2004).

In fact, there are some studies that prove MPSS is not related to MCS. Fitri & Pujiastuti (2020) research found that there was no significant relationship between MCS and MPSS, the effect was very small, only about 5.9%. Pratama et al. (2017) research found that the level of closeness between MPSS and MCS is in the low category, obtaining a value of $= 0.321$. Ariawan & Nufus (2017) research found that the level of relationship between students' MPSS and MCS is low, only 0,32. The similarity between these researches is they are using only quantitative approach. Ariawan & Nufus (2017) also said that there should be a more in-depth qualitative study to examine this phenomenon.

To answer this problem and avoid future misunderstanding, this study present a different and deeper view in finding relationship between students MPSS and MCS. Some of the previous researches were only using quantitative approach to see the relationship between students' MPSS and MCS (Junsay, 2016; Laia & Surven, 2023; Sumadi & Kusdinar, 2019; Wahyuningrum & Suryadi, 2014). This study will see how the relationship of these students' mathematics skills trough qualitative approach and describe it. Furthermore, in seeing the relationship of mathematics skills, researcher also tends to divide the test based on the number of variable (Fatimah, 2013; Nufus & Mursalin, 2020; Nursoffina & Efendi, 2021; Syafri et al., 2021). In this study, the relationship was analyzed based on students' answer using only one test and deep interview. Furthermore, not only the relationship but also the interaction between these mathematics skills, this study will show how is high, moderate and low problem soving students' MCS.

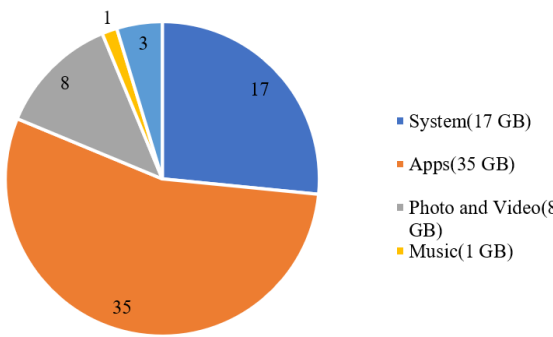
METHOD

Based on the purpose, this study is a qualitative research using a case study method. This method was chosen because this study needed a detailed and in-depth examination of students' MPSS and MCS. The participants of this study are 18 students from 8th grade. These students were chosen from 6 different cities in West Sumatra, namely Padang, Padang Pariaman, Padang Panjang, Bukittinggi, Payakumbuh, and Solok. Junior high schools is chosen because most of the international assessment were conducted in junior high schools where the students aged 15 years old or 8th grade in Indonesia. The sampling technique used is stratified random sampling, where each cities were chosen one

school-one class, each class were given mathematical test and three students were chosen. The choosing criteria is students with all/ almost all right answers, half right answers, and almost no right answers.

The main data source of this study are students' answer in mathematical test and interview. The students were given a mathematical test that can assess students' MPSS and MCS. The test used was from Musdi et al. (2024) research where the items can fulfill the indicators of MPSS and MCS. The indicators for PMSS used are (1) build new mathematical knowledge; (2) solve problems that arise in mathematics and in other contexts; (3) apply and adapt a variety of appropriate strategies; (4) monitor and reflect on the process (NCTM, 2000). The indicators MCS indicators are (1) organize and consolidate their mathematical thinking; (2) communicate coherently and clearly to peers; (3) analyze and evaluate others presentation; (4) use the language of mathematics precisely (NCTM, 2000). The test consist of three cases: smartphone storage with 2 problems, riddle about number of chickens and the coop, and area of land to be planted with corn. The mapping of the problems and indicators can be seen in Table 1.

Table 1. The mapping of test problems based on MPSS and MCS indicators

Table 1: The mapping of test problems based on MPSS and MCS indicators																				
Case	Problems	MPSS Indicators	MCS Indicators																	
Smartphone Storage	Pay close attention to Text 1 to answer Problem 1 and 2!	All	All																	
	Text 1  To make a documentary video assignment, Andi needs a 60 minutes video with an estimated size of 14 GB. Because Andi's smartphone storage was almost full, Andi had to delete several files/applications. 1. If the files or applications that can be deleted are indicated by the table below <table><thead><tr><th>File/App</th><th>Size</th></tr></thead><tbody><tr><td>Mobile Legends</td><td>6,6 GB</td></tr><tr><td>PUBG Mobile</td><td>11,2 GB</td></tr><tr><td>Lazada</td><td>0,35 GB</td></tr><tr><td>Photo Album 1</td><td>0,7 GB</td></tr><tr><td>Photo Album 2</td><td>1,5 GB</td></tr><tr><td>Indonesian Learning Videos</td><td>3 GB</td></tr><tr><td>Mathematics Learning Videos</td><td>1,85 GB</td></tr><tr><td>Music</td><td>1 GB</td></tr></tbody></table>	File/App	Size	Mobile Legends	6,6 GB	PUBG Mobile	11,2 GB	Lazada	0,35 GB	Photo Album 1	0,7 GB	Photo Album 2	1,5 GB	Indonesian Learning Videos	3 GB	Mathematics Learning Videos	1,85 GB	Music	1 GB	
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Case	Problems	MPSS Indicators	MCS Indicators
	What files/applications did you delete and explain your reasons? Show your calculations mathematically!		
	2. Present the contents/storage status of Andi's SmartPhone after inserting the documentary video assignment file in the form of a table and pie chart!	4	All
Riddle about Number of Chickens and the Coop	3. Mr. Arya has several chickens and several coops. When Mr. Arya placed 1 chicken in each cage, it turned out that 1 chicken was extra and he didn't get a cage. When Mr. Arya placed 2 chickens in each cage, it turned out that he had 2 extra cages. How many chickens and cages does Mr. Arya have? Explain your answer!	All	All
Area of Land to be Planted with Corn	4. Budi has a rectangular garden measuring 538 m x 114 m and will be planted with corn. If Budi's corn must be 0.6 m away from the next corn, illustrate Budi's garden after being planted with corn and count how many corn trees Budi planted in the garden!	1, 2, 4	All

Before using these mathematical problems, the problems were tested to 29 students to see the validity and reliability of the test. The result shows that the mathematical test are valid and reliable in assessing students' MPSS and MCS, where the score result of the test is bigger than t_{table} which is 0.367 for 5% significance and 0.470 for 1% significance. The validity and reliability test result can be seen in Table 2.

Table 2. The Result of Validity and Reliability Test

Problems	MPSS	MCS
Validity		
1	0.692	0.764
2	0.616	0.497
3	0.728	0.721
4	0.617	0.813
Reliability		
All	0.741	0.665

The mathematical test is done in 90 minutes. After the test, each three students were interviewed in group where students should present their answer and others listen and learn. The interview was an open interview to classify students' MPSS and MCS that can not be captured in the test and clarified their answer. The level of students' MPSS and MCS are decided based on the assessment rubric. The assessment rubric and key interview questions to assess can be seen in Table 3.

Table 3. MPSS and MCS Assessment Rubric

Indicators	Low	Moderate	High	Assessing/ Interview Process
MPSS				
Build new mathematical knowledge	Students cannot build new mathematical knowledge	Students build new mathematical knowledge but there are mistakes	Students can build new mathematical knowledge	In problems 1, 3, and 4 "What is the topic you used to answer the problem?"
Solve problems that arise in mathematics and in other contexts	Students cannot solve the problems given	students can solve the problem given but there are mistakes or can solve some half of the problems	Students can solve the problems and in other context problems	Based on their answer and presentation.

Indicators	Low	Moderate	High	Assessing/ Interview Process
Apply and adapt a variety of appropriate strategies	Students cannot solve a problem and did not find a strategy to solve the problem	students can solve the problem using routine method and cannot find alternative strategies	Students can solve the problem and have alternative strategies	In problem 1, "Do you think any other option to delete?" In problems 3 and 4, "Do you think any other procedure can be used?"
Monitor and reflect on the process	Students did not recheck their answer	students checked their answer but there are still mistakes in their answers	Students checked their answer and their answer is correct	In all problems, "Did you recheck your answer?"
MCS				
Organize and consolidate their mathematical thinking	Students cannot organize and consolidate their mathematical thinking based on their written and oral answer	Students can organize and consolidate their mathematical thinking based on their written and oral answer but there are mistakes	Students can organize and consolidate their mathematical thinking based on their written and oral answer	Based on their answer and presentation.
Communicate coherently and clearly to peers	Students cannot communicate coherently and clearly to peers	Students can communicate coherently and clearly to peers but there are mistakes	Students can communicate coherently and clearly to peers	Based on their answer and presentation.
Analyze and evaluate others presentation	Students did not understand peers explanation and cannot re-explain	Student understood peers explanation and cannot re-explain or Student understood peers explanation and can re-explain but there are mistakes	Student understood peers explanation and can re-explain	Based on the peer presentation, "Did you understand his/her idea? Can you reexplain?"
Use the language of mathematics precisely	Students cannot use language of mathematics	Students can use language of mathematics but there are mistakes	Students can use language of mathematics	Based on their answer and presentation.

To generalized the students' MPSS and MCS, for each indicators will be given score: 1 for low, 2 for moderate, and 3 for high. Students' level of MPSS and MCS will be based on Table 4.

Table 4. Students' MPSS and MCS

Category	Average score scale
High	Average score ≥ 1.5
Moderate	$0.5 \geq$ Average score > 1.5
Low	Average score < 0.5

After the students classification, the data was analyzed using descriptive analysis. Adapted from Khumainah et al. (2025), this analysis done in 3 stages, which are data reduction, data display, and conclusion/verification. In the data reduction, based on the students' classification in MPSS and MCS, students' answer in mathematical test and interview are grouped.

RESULT AND DISCUSSION

Based on the mathematical test and the following deep interview, the interaction between MPSS and MCS have 5 conditions/classes. The classes are 2 students with high MPSS and MCS, 6 students with high MPSS but moderate MCS, 4 students with moderate MPSS but high MCS, 3 students with

moderate MPSS and MCS, and 3 students with low MPSS and MCS. The interaction between MPSS and MCS and the students is presented in Figure 1.

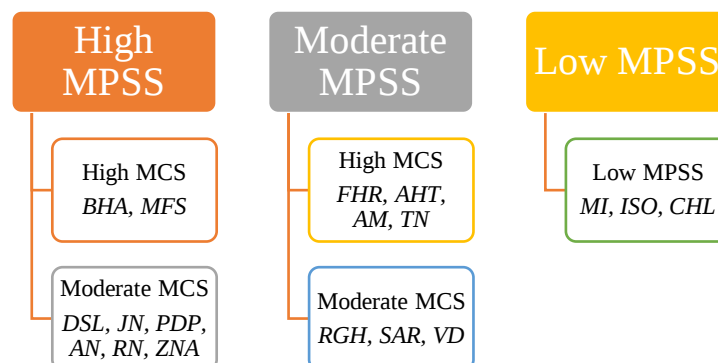


Figure 1. The interaction of Students' MPSS and MCS

Most of the High level MPSS students, which are 6 out of 8 students tends to have moderate MCS. Most of this happened because of the students misread and not careful in solving the problems. This happens a lot in the Problem 1 and 2. For example, ZNA answer in Problem 1 and 2 that can be seen in Figure 2.

secara matematis!

tempat kosong di penyimpanan smartphone Andi ada 3 GB. Andi membutuhkan tempat kosong sebanyak 14 GB untuk menyimpan video dokumenter. karena sudah ada tempat kosong sebanyak 3 GB. maka, $14 - 3 = 11$ Andi membutuhkan 11 GB lagi tempat kosong. Andi sedang kan untuk memenuhi persyaratan tersebut Andi tidak bisa menghapus aplikasi/file. Jadi, sebaiknya Andi menghapus PUBG Mobile, karena hanya dengan menghapus 1 aplikasi tersebut, persyaratan terpenuhi.

Aplikasi = 35
Foto & video = 22
Music = 1
Sistem = 6

Translation:
The space available in Andi's smarthphone is 3 GB. Andi need 14GB empty space to save the documenter video. Because the space available is 3 GB, then $14 - 3 = 11$ Andi need 11 GB more space, but to do that Andi cannot uninstall or delete lot of applications/ files. Then, it is better for Andi to uninstall PUBG mobile, because with only that application, he can do that.

Figure 2. ZNA's answer (Left=Problem 1, Right=Problem 2)

ZNA was answering Problem 1 with right answer but there is a sentence that makes her answer missed a little bit, which are "Andi cannot uninstall or delete lot of applications/ files". In the interview process, when interviewer ask "Why did you think like that?", She said "Hmm, I don't know, I'm just careless, maybe..". In the problem Problem 2, ZNA also made a mistake that make her answer is wrong, which is she was not subtract the "Application", even though she was picking PUBG to be uninstalled. In this perspective, interviewer decide that she can answer it but just careless just like

other students. To confirm it, at the end of Interview, when interviewer ask her, “If you are careful, can you answer it correctly?”, she said “Yes”.

For the students that have high MPSS and MCS, they have very good explanation based on their answers. For example, MFS’s answer in Problem 3. MFS answered using the trial and error method and he even mention it, which shows his high skill in communication. In the interview process, he also can present his answers and understand other students’ idea. MFS’s answer for Problem 3 can be seen in Figure 3.

Pakai metode coba?

Jika 1 ayam 1 kandang akan berlebih 1 maka tentu ayamnya akan lebih banyak 1 dibanding kandang

Jika 2 ayam 1 kandang maka berlebih 2 kandang tentu jumlah ayamnya genap.

Maka contoh: 6 ekor ayam dan 5 buah kandang

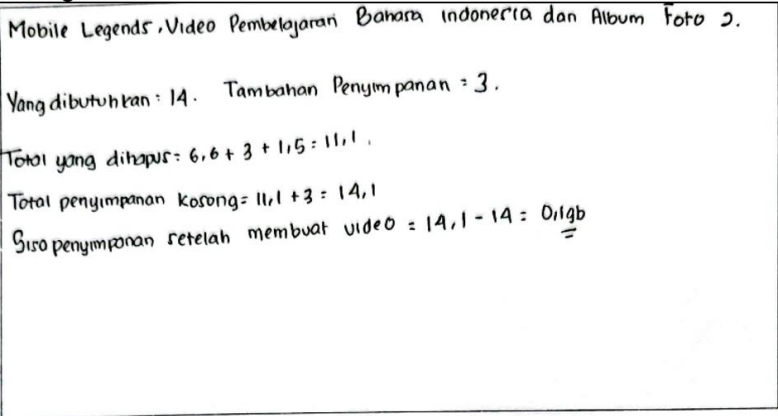
Jika 1 ayam 1 kandang:

Jika 2 ayam 1 kandang

Translation:
Using trial and error method
If 1 chicken for 1 coop, then one chicken doesn't have coop, then the chickens are more 1 than the coops.
And if 2 chicken for 1 coop, then there are 2 coops with no chicken, which means the number of chickens is even number.
Then, for example: 6 chickens and 5 coops

Figure 3. MFS’s answer for Problem 3

In the interview, interviewer ask him “Do you have other method to solve this problem?”. He answered with “For now, I don’t get any other idea”. The proper way to solve this problem is using algebra or system of two variable equations, but it does not come to his mind or he forget, and push him to have another method that is not routine. Based on his answer, it can be seen that he understand the problems, can process and present it. Furthermore, he can also use proper symbol and language, for example MFS’s answer for Problem 1 that can be seen in Figure 4.



Mobile Legends, Video Pembelajaran Bahasa Indonesia dan Album Foto 2.

Yang dibutuhkan: 14. Tambahan Penyimpanan = 3.

Total yang dihapus = $6,6 + 3 + 1,5 = 11,1$.

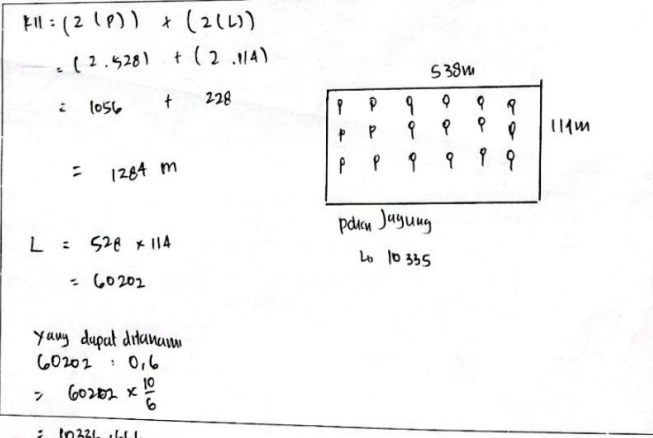
Total penyimpanan kosong = $11,1 + 3 = 14,1$

Sisa penyimpanan setelah membuat video = $14,1 - 14 = 0,1 \text{ gb}$

Translation:
Mobile Legends, Indonesian Language Learning Video, and Photo Album 2
Needed = 14, Available space = 3.
Erased total = $6,6 + 3 + 1,5 = 11,1$
Total available space = $11,1 + 3 = 14,1$
Available space after making video = $14,1 - 14 = 0,1 \text{ GB}$

Figure 4. MFS's answer for Problem 1

For the moderate level of MPSS students, the students with high and moderate MCS is almost equal. The difference is students' with high level MCS tends to understand all of the problems, can present some answer that they got, but also have no idea in some problems. FHR present this type of students especially in Problem 4. FHR's answer in Problem 4 can be seen in Figure 5.



$P11 = (2 \text{ (P)}) \times (2 \text{ (L)})$
 $= (2 \cdot 528) + (2 \cdot 114)$
 $= 1056 + 228$
 $= 1284 \text{ m}$

$L = 528 \times 114$
 $= 60202$

Yang dapat ditanam
 $60202 : 0,6$
 $> 60202 \times \frac{10}{6}$
 $= 10336,666 \dots$
 ≈ 10335 pohon jagung yang dapat ditanam di seluruh lahan

538m
114m
pohon jagung
Ls 10335

Translation:
Plantable
10335 corns are plantable in the cornfield

Figure 5. FHR's answer for Problem 4

FHR is very good at communication, he can present his answer clearly. He also can understand the problem really good, have idea in solving it but still has mistakes, in presenting Problem 4, the corn field is still not represent the actual condition, he should have added "... or ":" and the number of the corn. But, using " $\approx$ " is amazing. This is why his MCS is very high even though his answer is wrong, that he should divide the area of corn field with $0,6^2$. He also made a

mistake with conveting 0,6 to $\frac{10}{6}$ that should be $\frac{6}{10}$. In the interview process, interviewer also notice that he added a circumference of the corn field. But, it is not necessary. When the interviewer asked, “Why did you put circumference?”. He answered “I was just trying to find the way to solve the problem and I found it trough the area of the corn field”. This behavior shows that he is able to present his idea even though he made mistakes. Furthermore, in other aspect like understanding other students’ answer, he clearly understand their idea. At the end of interview, interviewer asked, “Based on this interview, can you solve this kind of problem?” and he answered “Hmm maybe, sir”.

For the students with moderate MPSS and MCS, students tend to misread or even don’t get the problrms fully. The students that presented by SAR, especially Problem 1, 2 and 4. Her answers for Problem 1, 2, and 4 can be seen in Figure 6.

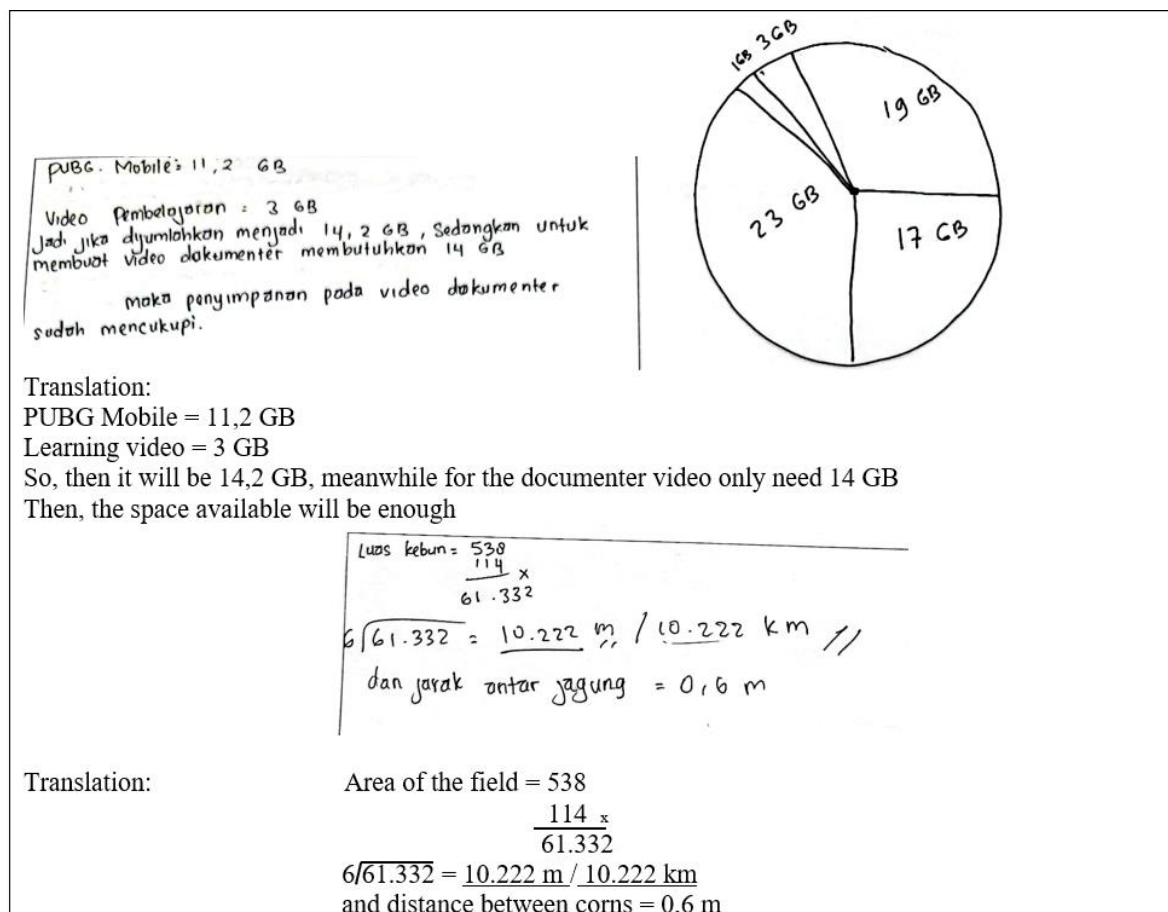


Figure 6. SAR's answer for Problem 1, 2, and 4

From these answer, it can be seen that for Problem 1 and 4, SAR did miss the problem. In Problem 1, she should show his mathematical calculation, even though she wrote the total is 14,2 GB. Furthermore, in Problem 4, she also missed and did not drew the ilustration of the corn field. Furthermore, just like some other students, in Problem 2, she also made a mistake in calculating the application and other items. In the interview process itself, she said that “Yeah, I did miss the problem

which cause my answer is not complete”. In the interview process, she was also not realize that she had mistake in answering the problems in Problem 4.

In the low level of problem solving, MI presents it. He has low level MPSS and MCS. In the interview, he said that he has no idea in solving the problems and even cheating. When the interviewer asked him to present, he could not do it and when the interviewer ask him “Can you follow what others idea in solving these problems” and he said “yes, but not the whole things. His written answer also shows that he has no idea in solving the problems. MI’s answer in problems 1 and 2 can be seen in Figure 7.

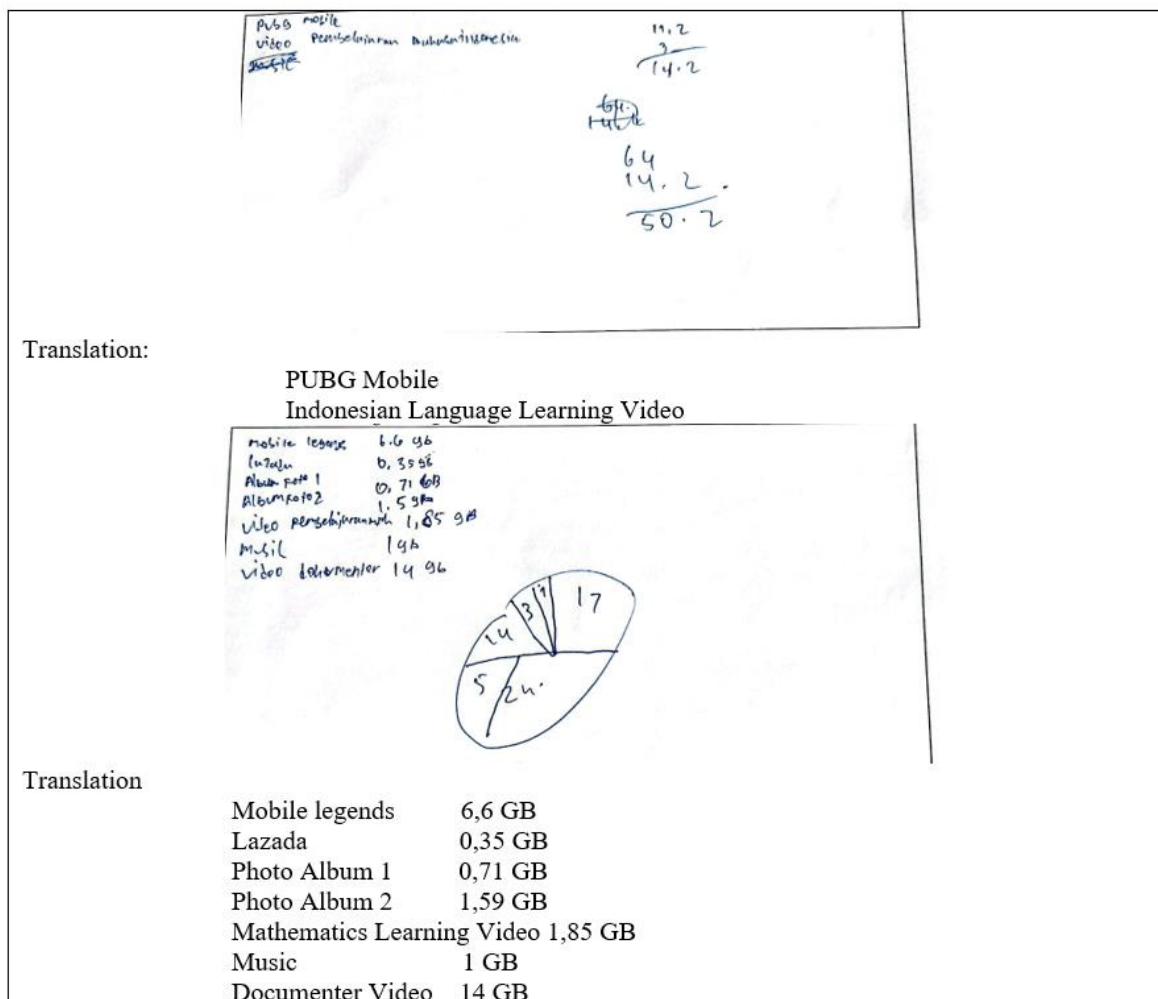


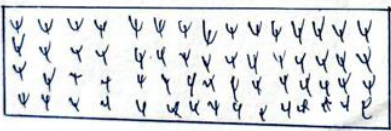
Figure 7. MI's answer for problems number 1 and 2

Based on MI's answer in Problem 1, it can be seen that he has no idea to solve the problems, and even did not understand the problems. In problems, Problem 2, he said that he only cheat to his friends. This is shows that he had a low MPSS and MCS ability. In Problem 3 and 4, he also the same behavior. No idea to solve the problems and for Problem 4, he was cheated. MI's answer for Problem 3 and 4 can be seen in Figure 8.

Dik: 1 ayam 1 kandang
 2 ayam 1 kandang
 1 ayam tidak ada kandang
 2 kandang kosong
 2 ayam = 1 kandang } karena Pak Arya ingin memasukkan 2 ayam
 1 ayam = 1 kandang } ke kandang
 Sisanya kandang Pak Arya = 2
 Jadi sisa kandang Pak Arya 2.

Translation:

Answer: 1 chicken 1 coop
 2 chickens 1 coop
 1 chicken does not have coop
 2 coops left
 2 chickens = 1 coop Because Mr. Arya want to put 2 chickens
 1 chicken = 1 coop 1 coop
 Mr. Arya's coop left = 2
 Thus, Mr. Arya's coop left is 2



jumlah perumpukan jagor
= 12.267.

Translation:

The number of corns
= 12.267

Figure 8. MI's answer for Problem 3 and 4

Based on the result, it can be seen that students' MPSS is actually alongside with their MCS. This result is similar to (Laia & Surven, 2023) research that found positive relationship between students' MPSS. Furthermore, in this study also shows that there is no students that have significant different like high MPSS but low MCS. This is also because it will be strange because the first thing students need to do in solving a problem is understanding the problem (Ningtyas, 2021; Wulansari & Walid, 2021). For the students in between, for example high level of mathematical problem solving but moderate problem solving, it can be concluded into high both or moderate both depends on the test and the amount of test (Al Mahrouq, 2016). Fitzpatrick & Yen (2001) suggested that tests should have at least eight 6-point items or at least 12 items with 4 or more score points per item to achieve acceptable reliability levels.

The finding about five classes in interaction between students' MPSS and MCS will be called as: high MPSS and MCS will be called solver, high MPSS but moderate MCS will be called self solver, moderate MPSS but high MCS will be called sharer, moderate MPSS and MCS will be called regular and low MPSS and MCS will be called receiver. The classification will be needed in future research like Harisman et al. (2023) research that divide students' mathematical literacy into three groups: the Time Stone, Power Stone, and Mind Stone. Or Harisman et al. (2021), Harun et al. (2019),

and Muir et al. (2008) researches that divide students' behavior in solving problems into four groups, which are naïve, routine, semi-sophisticated, and sophisticated. Rohati et al. (2022, 2023) research also did the same that he divide students' mathematical reasoning behavior into four groups: imitative, algorithmic, semi-creative, and creative. (Gunawan et al., 2019) divide students' behavior in understanding mathematical concept into three groups: instrumentalist, semi relationalist, and relationalist.

CONCLUSION

The interaction of students' mathematical problem-solving skills (MPSS) and mathematical communication skills (MCS) give 5 classes. The classes including solver, self solver, sharer, regular, and receiver. Sequentially, the classes are 2 students with high MPSS and MCS, 6 students with high MPSS but moderate MCS, 4 students with moderate MPSS but high MCS, 3 students with moderate MPSS and MCS, and 3 students with low MPSS and MCS. The results of this study also show that the relationship between MPSS and MCS is very close. Although there are students who have MPSS and MCS that do not match, this is inseparable from the limitations of the research conducted.

The limitation of this study is the test only use 4 problems that maybe cause some biases even though in assessing the students' MPSS and MCS, deep interview is also included. The number of participants is also limited which is only 18 students. In future research, next proper mathematical test need and need more participants that could join the study. Furthermore, in assessing students' mathematical skills, researcher also need to develop assessing method that can be done faster, so assessing students will be more effective, and the area of the research present the population of students. Based on this research, differentiated learning can also be done, developing learning materials using classes that found in this research is necessary, especially in Indonesia where "Merdeka" curriculum suggested differentiated learning.

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