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Common Difficulties of Eighth Grade Students When Solving Non-Routine Mathematics Problems

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Abstract: The study's objective is to investigate common difficulties experienced by 8th-grade students when solving non-routine mathematics problems. This study used a qualitative descriptive method, and the research participants were eighth-graders students at one of the private middle schools in Jakarta. The researchers used a convenience sample to obtain a group of six students available for an in-depth interview session and willing to solve two non-routine problems related to algebra topic. The study showed that the participants experienced difficulties when solving non-routine mathematics problems. They could not read the problem comprehensively; they had trouble converting the word problems into mathematical sentences. They also had difficulty in carrying out their plans. In other words, students did not have the strategy to solve the problem. They had errors in the calculation and had incorrect formulations when solving the given problems. It is suggested that the teacher provide students with guiding instructions to assist students in going through the problem-solving phases step by step. The teacher can also highlight the non-routine problem's keywords and give a representation that helps students understand the problem.

Keywords: learning difficulties, middle school students, mathematics problems

Abstrak: *Tujuan penelitian ini adalah untuk menyelidiki kesulitan umum yang dialami oleh siswa kelas 8 ketika memecahkan masalah non-rutin matematika. Penelitian ini menggunakan metode deskriptif kualitatif, dan partisipan penelitian ini adalah siswa kelas VIII di salah satu SMP swasta di Jakarta. Para peneliti menggunakan sampel kenyamanan untuk mendapatkan sekelompok enam siswa yang tersedia untuk sesi wawancara mendalam dan bersedia untuk memecahkan dua masalah non-rutin yang berkaitan dengan topik aljabar. Hasil penelitian menunjukkan bahwa partisipan mengalami kesulitan dalam menyelesaikan soal matematika non-rutin. Mereka tidak bisa membaca masalah secara komprehensif; mereka mengalami kesulitan mengubah kata masalah menjadi kalimat matematika. Mereka juga mengalami kesulitan dalam menjalankan rencana mereka. Dengan kata lain, siswa tidak memiliki strategi untuk memecahkan masalah. Mereka memiliki kesalahan dalam perhitungan dan memiliki formulasi yang salah ketika menyelesaikan masalah yang diberikan. Disarankan agar guru memberikan siswa dengan petunjuk petunjuk untuk membantu siswa dalam melalui tahap pemecahan masalah langkah demi langkah. Guru juga dapat menyoroti kata kunci masalah non-rutin dan memberikan representasi yang membantu siswa memahami masalah.*

Kata kunci: *kesulitan belajar, siswa SMP, soal matematika.*

▪ INTRODUCTION

Based on the National Council of Teachers Mathematics (NCTM) (Martin, 2000), problem-solving is one of the process standards for school mathematics. It means that in teaching and learning mathematics, it is expected that there is a problem-solving process. Moreover, as cited in Nurkaeti's study (2018) it is stated that problem solving is also the

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main aspect of mathematics teaching and learning because in learning mathematics, it includes solving the problems. On the other hand, based on the PISA (Program for International Students Assessment) result in 2015, the Indonesian score in mathematics is lower than average score (OECD, 2016). Besides that, Kurniati and Anizar (2017) shows that 15 years old students struggle to solve the given PISA problems, and they have a low performance in mathematical problem-solving ability. For example, the students struggle to build a connection between mathematical concepts, to organize and carry out their plan, and to check the correctness of the steps and answers.

Moreover, one of the private middle schools that used the Cambridge International General Certificate of Secondary Education (IGCSE) curriculum expects the students to have problem-solving skills. Although in their curriculum and learning activities, the school already tried to direct the students to get used to problem-solving, the teacher has not investigated their students' problem-solving strategies and difficulties yet. According to the initial finding of this study, the students did not look familiar with the problem-solving strategies. Then, they only used one strategy to solve non-routine problems related to algebra topics. Moreover, the students also have difficulties in problem-solving, particularly in carrying out their plan when solving the problems.

Based on previous study, it showed that from twenty participants, 5 participants produced no solution in problem 1, 8 participants performed problem-solving strategies but failed to get the correct answer for problem 1, and 7 participants performed problem-solving strategies and able to get the correct answer for problem 1 (Ratnasari, 2020). The result of the study indicates that the students experienced difficulties when solving non-routine problems which resulted in the incorrect answer. Considering the result of previous study, investigating students' difficulties when solving non-routine problems is needed. Thus, this study aims to investigate the common difficulties that experienced by 8^{th} grade students when solving two non-routine problems.

The researcher expects that this study can give a contribution for research in mathematics education especially in students' difficulties with mathematical problem-solving. In addition, the study is expected to be useful for teachers in schools to give information regarding their students' difficulties in solving non-routine problems. Besides teachers, this study might be useful for other researchers and people who are interested in mathematical problem-solving. The research question that would be answered in this study is what are the common difficulties that experienced by 8^{th} grade students when solving two non-routine problems?

Polya's Problem-Solving Strategy

Kaur (2008) mentioned that problem-solving is a complex process where an individual is required to relate prior experiences, knowledge, understanding, and intuition to fulfill the demands of a new situation. Problem-solving tasks usually include non-routine problems in which a problem solver has a no-readily available procedure to get a solution. It is the same as what NCTM in 1991 stated that the type of problem that can offer chances for the students to support and extend what students know and encourage mathematics learning is the non-routine problems (Kaur, 2008). Moreover, the worthwhile problems should involve students in exploring essential mathematical ideas and ways of thinking towards learning goals.

In Abdullah et al (2014), Daane & Lowry stated that problem solving activity may involve two types of problems, which are routine problems that use normal algorithm and non-routine problems that require students to use high level of interpretation and problem-

solving management. In addition, based on NCTM as cited in Cai & Lester (2010), there are ten criteria of non-routine problems but many researchers and curriculum developers (i.e., Hiebert & Wearne, 1993; Marcus & Fey, 2003; NCTM, 1991; van de Walle, 2003; Lappan & Phillips, 1998; Cai, Moyer, Wang, & Nie, in press) dispose to agree that the first four criteria (i.e., essential mathematics, higherlevel thinking and problem-solving, conceptual development, and opportunity in assessing students' learning) need to be considered as the main selection of all problems.

To define students' problem-solving ability, George Polya stated that there are four phases in the problem-solving process. The phases are: understanding the problem, devising a plan, carrying out the plan, and looking back. Polya also mentioned those four phases in his book "How to solve it" in 1957. Table 1 shows those four phases in Polya's problem-solving strategies including the indicators in each phase.

Table 1. Polya's Problem-Solving Strategy Aspects

Aspect of Problem-Solving	Aspect
Understanding the problem	● Identify aspects are known on the problem ● Mention the information based on the problem ● Connect the problem with another topics on mathematics
Devising a plan	● Make a mathematical form based on the problem ● Show mathematical concept that would be used to solve the problem
Carrying out the plan	● Analyze the process of the problem-solving based on a plan
Looking back	● Check the accuaracy of answer with the questions

Common Difficulties in Mathematical Problem-Solving

According to Kaur (1997), students may encounter several common difficulties when solving mathematical problems. The first type is the inability to comprehend the issue, which commonly happens when students are given problems they cannot read them thoroughly. The second type is inadequate comprehension of the problem. This difficulty indicates that the students can read the problem clearly but cannot comprehend a particular text or the entire problem. Next is the lack of strategy, which means that when students attempt to solve problems, they frequently lack the knowledge necessary to perform their strategy. Another type of difficulty is an ineffective strategy was employed. Because in most cases, a problem can be solved through a combination of strategies that result in one or more solutions. However, students must use appropriate strategies to obtain the correct solution. The fifth type is the inability to formulate the problem mathematically. This means that students cannot convert the problem (if it is a word problem) to a mathematical sentence or form. Another difficulty is the incorrect mathematical formulation. This indicates that the student attempted to create a mathematical form but could not make the correct formula, resulting in a wrong answer. Lastly is the errors in computation, which occasionally happens. The calculation error could be the result of carelessness when students solve problems.

▪ METHOD

To answer the research question, researchers used a qualitative descriptive method to present the event summaries that were experienced by a group of people comprehensively. In this case, it is the description and interpretation of students' difficulties when solving two non-routine problems. The interpretation and descriptions were made by the researchers based on fact. Then, the researchers also presented the data descriptively. As cited by Clinton & Vickie (2012) Sandelowski mentioned that the qualitative descriptive method is the least theoretical approach based on naturalistic investigations and views of something in its natural state.

The researchers involved twenty participants who are 8th grade students in a private middle school in Jakarta. According to the International General Certificate of Secondary Education (IGCSE) curriculum, 8th grade students already learned about linear equation one variable and simultaneous equation (CIE, 2016). Therefore, the researchers thought that it would be possible if 8th grade students are given two non-routine problems related to those two topics. Moreover, the researchers use a convenience sample (non-random sampling method) to select a group of individuals that is conveniently available to be studied. Six participants (i.e., S1, S4, S5, S9, S21, S22) were conveniently available to solve two non-routine mathematics problems and to participate in the interview session. Creswell (2012) stated the objective of convenience sampling is that researchers can choose the subjects who are available to be studied and can get a deeper understanding about the phenomenon and researchers can get a deeper understanding about the phenomenon. Other than that, the reason why the researchers chose those six interviewed subjects because they gave the researchers a variety and richness for the findings. Thus, it can help the researchers to answer the research question of the study related to students' difficulties when solving non-routine problems.

The researchers collected the data by using a test, classroom observation, interview, and review participants' worksheet. In the test, there are two non-routine problems (i.e. word problems) about linear equations one variable and simultaneous linear equations two variables. In addition, those two problems have different levels of complexity. The non-routine problems on the test are shown in Table 2.

Table 2. Non-routine problems on the test

No.	Description
1	Crisbert has a jar of chocolate candies. He gave Jodie a portion of the candies. Naira was given the candies that Jodie had left. Then came Henry. Crisbert gave Henry remaining candies. Then, Yahya was given a portion of the candies left in the jar. Finally, there were only fifty candies left in the jar. How many candies were originally in the jar? *(The problem is modified from Manggoes Problem in http://illuminations.nctm.org/)* 

2	At lunch time, Nickyta went to Starbucks to buy coffee for herself and some of her friends. A grande size cup of coffee cost $4 and a tall size cup of coffee cost $3. She spent $17 for 5 cups of coffee. How many cups of coffee did she buy for each size of coffee? *(The problem is modified from Math Olympiad Unleash The Maths Olympian in You!, 2010)*	

The test intended to investigate students' difficulties when solving non-routine problems. After designing the instruments, the researchers validated the instruments to the experts who are mathematics lecturers in a private university. Then, to check the reliability of the instrument, the researchers gave the test with similar problems to another 8^{th} grade class. Furthermore, the researchers gave test to all twenty 8^{th} grade students, and the researchers asked the students to write the steps on how to find the final answer by using their own strategy. The researchers instructed the students to use more than one strategy to get a solution on the problems.

After the students were given a test, the researchers conducted a semi-structured interview with the interviewed subjects. This kind of interview allows flexibility and gives the participants to relax due to the interview (Cohen, Manion, & Morrison, 2018). Besides, the researchers used the interview questions from Lester & Kroll in 1996 as cited in Kaur (2008), and the interview questions are categorized based on Polya's problem solving phases. There are four phases of problem-solving process, which are understanding the problem, devising a plan, carrying out the plan, and looking back (Polya, 1957). This interview intended to get more information related to interviewed subjects' difficulties when solving non-routine problems. The researchers recorded the interview between a researcher and interviewed subjects. After giving the test to the participants, the researchers analysed the data based on the participants' worksheet, observations, and interviews result. Then, the researchers analyzed the data based on common difficulties experienced by the participants when solving the problems as mentioned by Kaur (1997).

▪ RESULT AND DISSCUSSION

In general, the researchers found five difficulties experienced by students when solving the given problems—these difficulties related to students' difficulties in mathematics problem-solving that are mentioned by Kaur (1997). In addition, the researcher also categorized the difficulties based on Polya's problem-solving aspects already shown in Table 1. Polya's problem-solving aspects and indicators are used to identify which aspect of participants' difficulties.

Moreover, the analysis result shows that the most dominant difficulty was carrying out the plan. Although, some participants still experienced difficulty understanding the problem and devising a plan. The participant has difficulty carrying out the plan because they rarely write the steps on how to get the solution to the problem. Then another reason is that the students are also have not familiar with problem-solving strategies and solving non-routine mathematics problems. Furthermore, there were five types of difficulties commonly experienced by the participants when solving non-routine mathematics problems. Participants had difficulty in reading the problem comprehensively. The participants were able to read the problem, but they could not understand the text coherently. This difficulty is caused by a lack of understanding of the problem. This

difficulty falls into the first aspect of Polya's problem-solving (i.e., understanding the problem). Figure 1 shows that students experienced difficulty in all aspects, including reading the problem comprehensively.

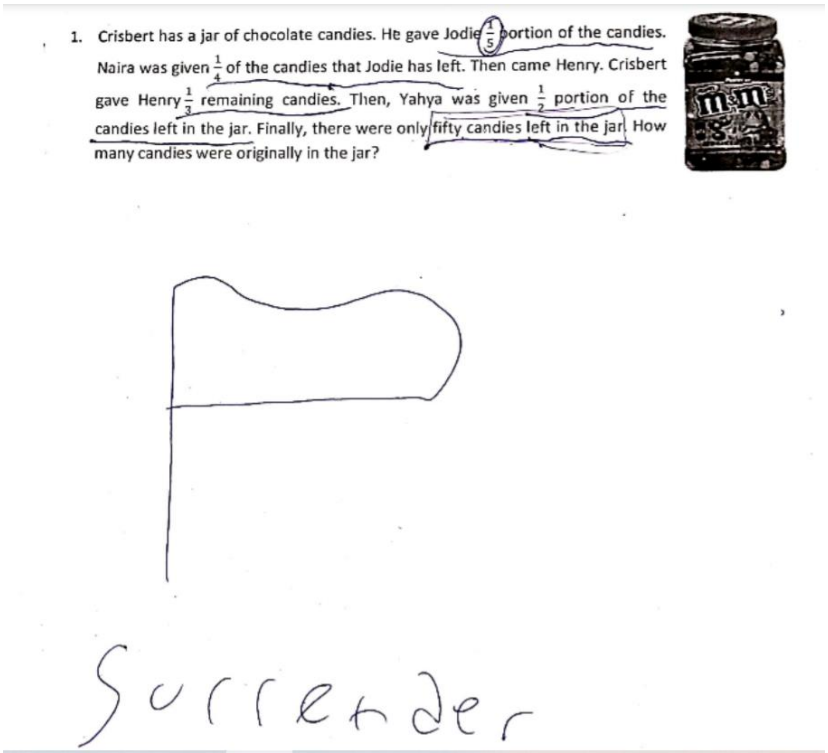

Figure 1. Example S5's difficulty on all problem-solving aspects

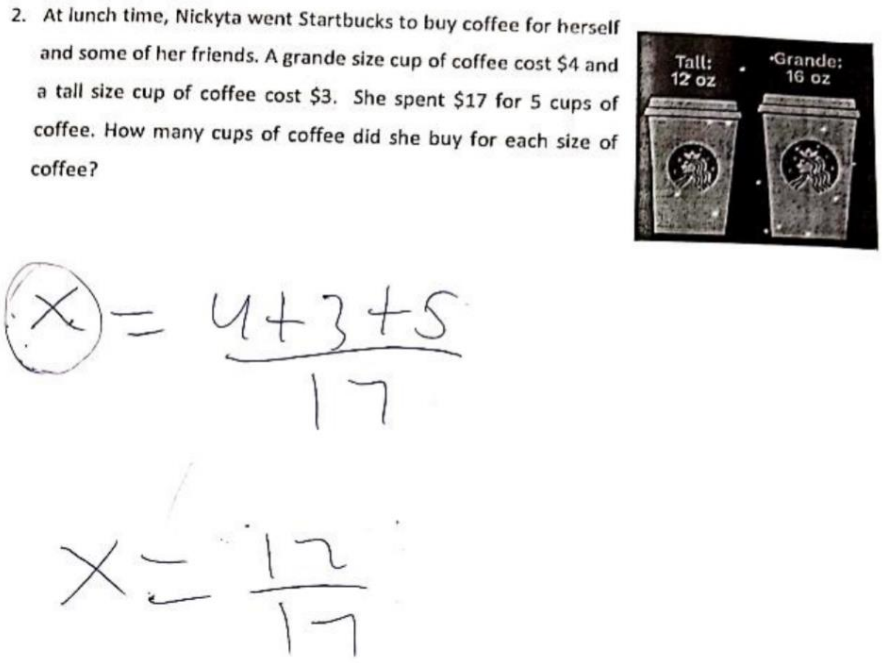

Figure 2. Example of S5's difficulty on all problem-solving aspects

S5 is one of the interviewed subjects who had difficulty solving the given problems, 1 and 2. S5's answer to problem 1 is shown in Figure 1 & 2. In problem 1, he did not attempt the strategy at all. He just drew a flag on his answer sheet. Moreover, he could read the problem but could not make sense of the text on the given problem. The reason is the lack of understanding of the problem comprehensively. Another reason he mentioned during the interview is difficult for him to translate the problem into the mathematical form or mathematical sentence. This difficulty can be caused by a lack of mathematics terms and language. Then, he also did not know how to solve problem 1, which is why he did not attempt the strategy on his answer sheet. This difficulty is caused by a lack of strategic knowledge in solving the problem. It concludes that S5 has difficulties in difficulties in four problem-solving aspects. This difficulty also related to the findings in Saygili's study (2017), the participant did not use the clear strategy and the operation do not make sense and resulting the incorrect answer. Besides in Saygili's study (2017) found the same result as this study, which is participant only write random numbers in the solution part without thinking because he/she did know what need to do.

Participants also had difficulty in converting the problem (i.e., word problems) into a mathematical sentence or mathematical form. This difficulty falls into the second aspect of Polya's problem-solving (i.e., *devising a plan*). The example of this student's difficulty is shown in Figure 3. The third type of difficulty is the participants had a problem in carrying out their plans. In other words, students did not know how to do with the strategy. This difficulty is caused by a lack of strategic knowledge in solving the problem. This difficulty falls into the third aspect of Polya's problem-solving (i.e., *carrying out the plan*) and the example of this difficulty is also shown in Figure 1 & 2. Participants also had an error in the calculation when solving the given problems. It is caused by involving carelessness. This difficulty falls into the third aspect of Polya's problem-solving (i.e., *carrying out the plan*), and the example is shown in Figure 3.

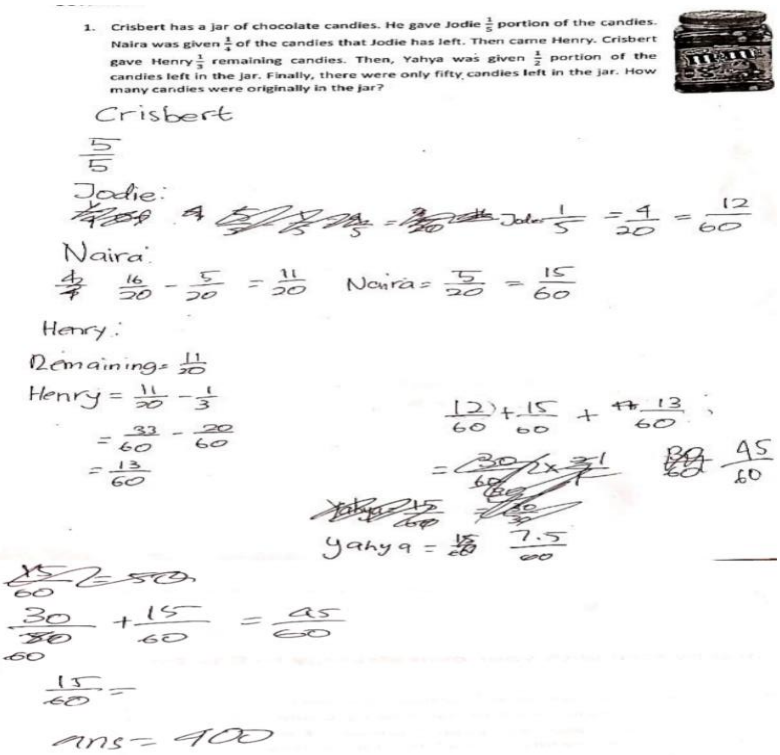

Figure 3. Example of S1's error in calculation when solving problem 1

Figure 3 is an example of S1's answer. S1 tried to perform a problem-solving strategy using a systematic list to solve problem 1, but S1 failed to get the correct answer. S1 did miscalculate; thus, S1 got an incorrect answer because of carelessness when solving problem 1. S1 excused that since the time was almost up, S1 was in a hurry and became careless in finding the correct solution. The interview result supports S1's statement.

S1: "Oh, it supposed to be 40 Miss. Oh my gosh, I guess I miscalculated, so my answer is wrong. I was in a hurry at that time. I am sorry, Miss."

Participants had incorrect formulation when solving the given problems. This difficulty falls into the third aspect of Polya's problem-solving (i.e., carrying out the plan). The example of this difficulty is shown in Figure 4.

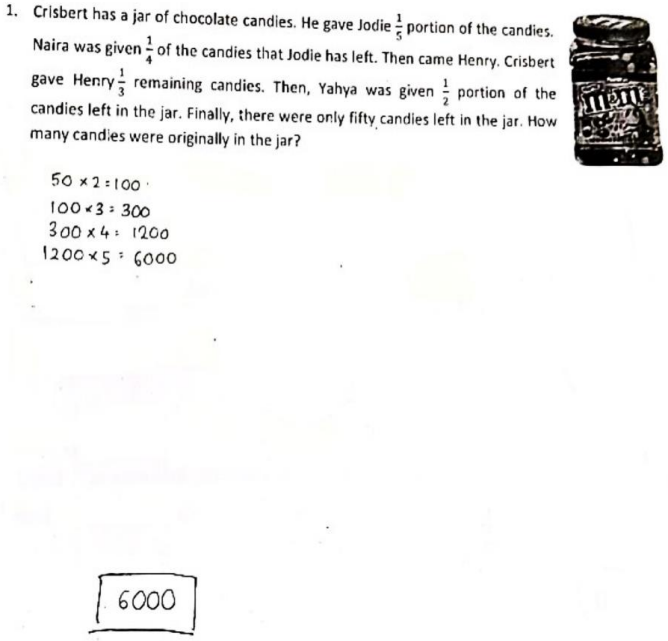

Figure 4. Example of S9's incorrect formulation when solving problem 1

In Figure 4, S9 performed a backward strategy to get the solution in problem 1. Unfortunately, S9 got an incorrect answer because S9 had incorrect formulation when solving the problem, especially in step 2. S9 thought that if a half of candies left in the jar is 50, so the number of Candies before Yahya took is 100. Afterward, she assumed that 100 is a third or the portion that Henry took. Then, she also assumed that if the remaining candies of Naira are 300, so Jodie left 1200 candies in a jar. S9 got 6000 from 1200 multiply by 5 because S9 thought that $\frac{1}{5}$ of candies in the jar is 1200. It is the same as S9 mentioned in the interview.

S9: "...there were 50 candies left in the jar after Yahya took. So, since Yahya got $\frac{1}{2}$ of the remaining candies, then after Yahya took the candies there were 50 left. So, I thought that before yahya took is 100. So I just multiplied 50 by 2 that's equals to 100. Then, since Henry got $\frac{1}{3}$ of the remaining candies of what Naira was left, I thought that the candies will be 100 times 3 and equals to 300. After that, before

Naira took $\frac{1}{4}$ of the remaining candies that Jodies has left, I just multiplied 300 by 4 so it equals to 1200. Then, Crisbert has 1200 times 5 before he gave Jodie the candies. It equals to 6000. So ya that is my answer."

Based on the findings, some participants were unable to get the correct answer and produced no solution. The reason is that the participants experienced difficulties in solving the given problems, especially on problem 1. For examples, the students experienced the difficulties in reading the problem comprehensively, converting the problems into mathematical sentence, carrying out their plans, had an error in calculation, and had incorrect formulation when solving the given problems. These findings of students' difficulties when solving the problem are related as mentioned by Kaur (1997) and some students' difficulties in this study are the same as findings in Nurkaeti's study (2018), Barake's study (2015),Tambychik & Meerah (2010), Novriani & Surya (2017), Phonapichat et al. (2014) and Lubis et al. (2017). Furthermore, from those five common difficulties that experienced by participants, the most dominant difficulty is in carrying out the plan. The reason why this difficulty is dominant because when the participants are given the problems they rarely write the steps on how to get the solution. Thus, it might cause them difficult to write and carried out their plan or steps to get the solution on the problem.

Barake (2015) and Nurkaeti (2018) involved the participants who were unfamiliar with mathematics problems in English. Then, they found that some students (i.e. participants of the study) can read the text of the problems but they had difficulty in understanding the problem comprehensively. Although only some participants can read the problem in English, it does not mean they can understand the problem comprehensively. This difficulty also happened when S5 (i.e. subject of the study) solving the given problems. S5 are usually given mathematics word problems in the classroom and S5 can read the text of the given problem. Unfortunately, S5 failed in reading comprehension toward the problem given. If it is compared between the findings in this study with Barake and Nurkaeti, it does not mean that if the students who are usually given mathematics word problem in English did not have difficulty in problem-solving especially in understanding towards the problems.

▪ CONCLUSION

Based on the findings, it can be concluded that the participants solved the given problems and were experiencing difficulties. Then, here are five common difficulties were experienced by participants when solving the given problems, which are: difficulty in reading the problem comprehensively, in converting the problem into mathematical form, in carrying out the plan, had a calculation error, had incorrect formulation. Due to those five difficulties, it indicates the students experienced difficulty in Polya's problem-solving aspects (i.e. understanding the problem, devising a plan, carrying out the plan, and looking back).

According to the findings, it indicates that the students faced difficulties when solving non-routine problems. Thus the teacher can use the strategy by guiding questions or instructions related to problem-solving phases to develop the skills. The teacher also can use strategy, which highlights the keywords of the problem and make a representation of the problem to help students with have difficulty in understanding the problem (Baraké et al., 2015). Furthermore, this descriptive qualitative study also has a limitation in terms

of the test duration. Thus, in further study, the researchers need to extend the time of the test.

▪ REFERENCES

Abdullah, A. H., Ibrahim, N. H., Surif, J., Ali, M., & Hamzah, M. H. (2014). Non-routine mathematical problems among in-service and pre-service mathematics teachers. *2014 IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE)*.

Baraké, F., El-Rouadi, N., & Musharrafieh, J. (2015). Problem Solving at the Middle School Level: A Comparison of Different Strategies. *Journal of Education and Learning*, *4*(3), 62–70.

Cai, J., & Lester, F. (2020). Why is Teaching with Problem Solving Important to Student Learning? *Nctm*, *13*(12), 1-6. Retrieved from https:// www.nctm.org/uploadedFiles/Research_and_Advocacy/research_brief_and_clips/ Research_brief_14_-_Problem_Solving.pdf

Cohen, L., Manion, L., & Morrison, K. (2018). *Research Methods in Education* (8th ed.). New York: Routledge.

Creswell, J. W. (2012). Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research (4th ed.). New York: Pearson College Division.

Kaur, B. (2008). *Kaur (2008).pdf*. Singapore.

Kaur, B. (1997). *Difficulties with problem solving in mathematics*. *2*(1), 11.

Kurniati, D., & Annizar, A. M. (2017). The analysis of students' cognitive problem solving skill in solving PISA standard-based test item. *Advanced Science Letters*, *23*(2), 776–780.

Lambert, V. A., & Lambert, C. E. (2012). Editorial: Qualitative Descriptive Research: An Acceptable Design.: EBSCOhost. *Pacific Rim International Journal of Nursing Research*, (4), 255–256. Retrieved from http://web.b.ebscohost.com/ehost/pdfviewer/pdfviewer?vid=1&sid=5f9e3290-c434-45a6-a69c-d9fa69ec3cce%40pdc-v-sessmgr02

Lubis, J. N., Panjaitan, A., Surya, E., & Syahputra, E. (2017). Analysis Mathematical Problem Solving Skills of Student of the Grade VIII-2 Junior High School Bilah Hulu Labuhan Batu. *International Journal of Novel Research in Education and Learning*, *4*(2), 131-137.

Martin, W. G. (2000). *Principles and Standards for School Mathematics*. National Council of Teachers of Mathematics.

NCTM (n.d) https://www.nctm.org/Classroom-Resources/Illuminations/Lessons/Classic-Middle-Grades-Problems-for-the-Classroom/

Novriani, M. R., & Surya, E.. (2017). Analysis of Student Difficulties in Mathematics Problem Solving Ability at MTS SWASTA IRA Medan. *International Journal of Sciences: Basic and Applied Research (IJSBAR), 33(3), 63-75.*

Nurkaeti, N. (2018). Polya'S Strategy: an Analysis of Mathematical Problem Solving Difficulty in 5Th Grade Elementary School. *EduHumaniora | Jurnal Pendidikan Dasar Kampus Cibiru*, *10*(2), 140.

OECD. (2016). Country note – results from PISA 2015: Indonesia. *Oecd*, 1–8. Retrieved from https://www.oecd.org/pisa/PISA-2015-Indonesia.pdf

Phonapichat, P., Wongwanich, S., & Sujiva, S. (2014). An analysis of elementary school students' difficulties in mathematical problem solving. *Procedia - Social and*

Behavioral Sciences, *116*, 3169-3174.

Polya, G. (1957). How To Solve It. In *The Mathematical Gazette* (2nd ed.).

Ratnasari, R., & Safarini TLS, D. (2020). Problem-Solving Strategies Used by Eight Grade Students. *Contemporary Mathematics and Science Education, 1*(2), ep20008.

Saygılı, S. (2017). Examining The Problem Solving Skills and The Strategies Used by High School Students in Solving Non-routine Problems, *E-International Journal of Educational Research, Vol: 8, No: 2, 2017, pp. 91-114.* Retrived from http://static.dergipark.org.tr/article-download/701a/4b75/8667/59adca7d2719f.pdf?

Tambychik, T., & Meerah, T. S. M. (2010). Students' difficulties in mathematics problem-solving: What do they say? *Procedia - Social and Behavioral Sciences*, *8*, 142–151.