第 48 卷 第 9 期
2021 年 9 月

湖南大学学报（自然科学版）
Journal of Hunan University (Natural Sciences)

Vol. 48. No. 9.
September 2021

Analysis of Students' Mathematical Problem-Solving Skills

Intan Kemala Sari[1]*, Ahmad Nasriadi[1], Riza Agustiani[2], Rahmat Nursalim[3], Jarudin[4]

[1] Program Studi Pendidikan Matematika, Universitas Bina Bangsa Getsempena, Banda Aceh, Indonesia

[2] Program Studi Matematika, UIN Raden Fatah, Palembang, Indonesia

[3] Program Studi Matematika, Universitas Bengkulu, Bengkulu, Indonesia

[4] Department of Information Technology, Institut Teknologi Bina Sarana Global, Tangerang, Indonesia

Abstract: Problem-solving ability is a mathematical ability mandated to develop through learning mathematics. This study aims to determine how students' mathematical problem-solving abilities are seen through their ability to solve problems in algebraic forms. This research was conducted on 69 students in three districts in Aceh Province, Indonesia. It used qualitative methods in three kinds of instruments. From this research, the questionnaire results showed that students had good problem-solving abilities, but based on test and interview questions, it was found that students' problem-solving abilities were in a fairly good or moderate category. The research found that students are unable to reflect and recheck their answers because they do unperfect preparation in the problem-solving cycle. This research was conducted during the COVID-19 pandemic condition, with three days of school a week. The research subject is the students of the transition period between primary to secondary education. The mathematical problem-solving skills are unstable. Through the results of this study, it is hoped that educators can optimize efforts to develop mathematical problem-solving abilities because they are important in learning. The research novelty lies in communication techniques applied by students in completing mathematical problem-solving.

Keywords: problem-solving, COVID-19, algebra.

学生数学解题能力分析

摘要：解决问题的能力是通过学习数学来培养的数学能力。本研究旨在确定如何通过学生解决代数形式问题的能力来看待学生的数学问题解决能力。这项研究是针对印度尼西亚亚齐省三个地区的 69 名学生进行的。它在三种仪器中使用了定性方法。本次调查问卷结果显示，学生的问题解决能力较好，但从测试和面试问题来看，学生的问题解决能力处于较好或中等水平。研究发现，学生无法反思和重新检查他们的答案，因为他们在解决问题的周期中没有做好准备。这项研究是在新冠肺炎大流行期间进行的，每周上学三天。研究对象为中小学过渡期的学生。数学解题能力不稳定。通过这项研究的结果，希望教育者能够优化努力发展数学解决问题的能力，因为它们在学习中很重要。研究新颖性在于学生在完成数学问题解决中应用的交流技巧。

关键词：解决问题，新冠肺炎，代数。

Received: May 1, 2021 / Revised: June 6, 2021 / Accepted: August 1, 2021 / Published: September 30, 2021

About the authors: Intan Kemala Sari, Ahmad Nasriadi, Program Studi Pendidikan Matematika, Universitas Bina Bangsa Getsempena, Banda Aceh, Indonesia; Riza Agustiani, Program Studi Matematika, UIN Raden Fatah, Palembang, Indonesia; Rahmat Nursalim, Program Studi Matematika, Universitas Bengkulu, Bengkulu, Indonesia; Jarudin, Department of Information Technology, Institut Teknologi Bina Sarana Global, Tangerang, Indonesia

1. Introduction

Providing students with the opportunity to develop their problem-solving skills in the mathematical learning process can improve their critical thinking skills [1], [2]. This can increase the value of objectivity and rationalism in concluding a conclusion of the problem [3]. In the process of learning mathematics, the lack of non-routine problems presented in the sourcebook (text) when teachers are accustomed to adopting the questions contained in the sourcebook becomes undeniable [4].

Procedurally on trivial questions, more can be solved by students quickly. However, when students are given problem-solving questions, they face many difficulties, such as understanding weak concepts and facts, applying and analyzing procedures to reflect the results of the answers [5]. In addition, the ability of students to learn abstract concepts in learning mathematics is also very important. Students who have not achieved age-appropriate cognitive abilities [6] also do not meet the ideal criteria in terms of the ability to master more complex concepts.

Judging from the Program for International Students Assessment (PISA) results, problem-solving skills for Indonesian children are quite low [7]. Students' math skills in PISA research are closely related to mathematical literacy. PISA provides an overview of students' ability to apply mathematics in various situations[8]. The government uses PISA results to monitor the development of the Education system in a country. Pisa results describe the character of the education system to predict people's future productivity [9]. PISA is one of the important references in measuring the success of education, including in the field of mathematics.

PISA uses test questions in the form of real situations that must be resolved by students aged 14-15 years. PISA wants to measure the understanding of student concepts in applying contextual problem solving, which is closely related to its life[10]. PISA provides an understanding of mathematics not tested in solving problems directly. In its implementation, students should utilize active thinking through investigation and solve problems before applying their mathematical knowledge [11]. Meanwhile, students' ability to formulate, engage and interpret mathematics in various contexts, including those that can be utilized in solving PISA problems, into mathematical literacy skills [12]. The better the students' math literacy, the better their ability to analyze and solve the problem.

PISA questions demand reasoning and problem-solving skills for students in some situations. The student is said to be able to solve problems if he can apply his knowledge in analyzing and conducting investigations that have been obtained in his learning experience into new situations that have not been known before [13]. A person is considered to have a level of mathematical literacy if he can analyze, reason, communicate his math knowledge and skills effectively and solve and interpret mathematical problems in various situations related to summation, form and space, probability, or other mathematical concepts [10]. This means that problems according to PISA standards are good enough to measure students' abilities after learning mathematics because they measure students' mastery in mathematical concepts and use them in everyday problems.

PISA problems can stimulate students to solve problems through their own concepts even if they are unaware of using mathematical concepts properly [14]. Why is that? This is because PISA has a mathematical literacy concept that is the ability of a person to formulate, use, and interpret mathematical concepts in various contexts of problems he recognizes [15]. Thus, PISA and literacy cannot be separated from the concept of individual proficiency in the 21st century; therefore, the relationship between mathematical concepts and problem-solving skills becomes an important part of human survival[16], [17].

Based on the background of problems and theoretical studies stated above, it is known how important problem-solving skills are in individual students to succeed in learning mathematics. Students who have good mathematical problem-solving skills can support their life for the future of technological competition. Thus, this study aims to determine how students' mathematical problem-solving skills develop based on PISA indicators if given problem-based problems. Novelty in this study Communication techniques students in completing the solve the problem of mathematics. The findings of this study are expected to contribute to the world of Education to recommend improving the quality and achievement of mathematics learning as a whole.

2. Method

This study was conducted on 69 grade VII junior high school students in several districts in Aceh Province. This study uses the qualitative approach, including measurement instruments, questionnaires, tests, and interviews. The data was collected by providing questionnaires about students' perception of problem-solving skills, five PISA model math questions on algebraic forms, interviews to clarify test answers, and further perception analysis of students' mathematical problem-solving skills.

The formulation of questionnaire questions is developed based on indicators of problem-solving ability conducted using the Polya theory consisting of (1) understanding the problem, (2) devising the plan, 3)

solving problems according to the plan (carry out a plan), and 4) re-examining the results obtained (looking back at the completed solution) [18]. At the same time, the development of the test question refers to the PISA model validated by three experts. To withdraw valid conclusions, unstructured interviews were conducted to review the questionnaire results further, obtain the test findings, and highlight the novelty of the information obtained.

Data analysis techniques were applied using the Likert interval scale because it measures the nature of individuals using a total score [19]. In addition, the Likert scale also has a more measurable level of calculation objectivity [20]. Triangularization of sources was carried out to test the validity of the data based on the prepared research instruments. Triangulation is a method of data synthesis to provide confidence about the validity of data taken from research; therefore, there is no doubt in the conclusion results [21]. Through the triangulation of data from three technical collections, the analysis results taking into account positive acceptance on two of the three existing aspects become accountable. This fact reinforces the assumption that the conclusions drawn have a high degree of validity.

3. Results and Discussion

This research was conducted in three stages: filling out questionnaires, giving test questions, and conducting interviews. Questionnaire filling is done to find out how the condition and level of students in solving math problems. The test questioning is done to determine if the student has mathematical problem-solving skills that can be measured based on the student's answer results in writing. At the same time, unstructured interviews are conducted to confirm again if there is a difference between the results of the questionnaire and the completion of the test question. The following will be described the results of the analysis of the three research instruments.

Based on indicators from NCTM, problem-solving capabilities are divided into four indicators, namely, (1) building new mathematical knowledge through problem solving, (2) solving problems that arise in mathematics and other contexts, (3) implementing and adapting various appropriate strategies to solve problems, (4) re-examining and reflecting on the process of solving mathematical problems [22]. Based on the indicator, 27 points of questionnaire questions were developed; the results obtained are given in Table 1.

Table 1 shows the percentage of students' answers to poll questions converted based on mathematical problem-solving indicators. Based on the average score per indicator and using the Likert scale, it is known from the table that mathematical problem-solving skills, according to student perception, fall into the good and excellent category. In this case, the students assess themselves regarding the ability and habits that correspond to the problem-solving indicator.

Table 1 Student perception questionnaire results

Indicator	Totally agree (%)	Agree (%)	Simple agree (%)	Less disagree (%)	Disagree (%)
Knowledge	33.33	34.78	15.94	7.24	8.69
Plan	21.73	32.60	18.84	9.42	10.14
Apply	46.37	26.08	15.94	4.34	7.24
Evaluation	43.47	34.78	10.14	4.34	7.24

The most dominant thing assessed by the students is the application and adaptability of various strategies when solving math problems. This is known from the highest percentage of what students like the most and often do based on indicators of contentment points. While students do not like problem-solving or rarely solve problems through both mathematical and other contexts. This result can be seen in the highest percentage of things students like the least.

The two tendencies of perception can be interpreted as follows: students like or often solve math problems by applying and adapting a strategy without using a particular context, either mathematical or non-mathematical, which indicates that the student is acting towards problem solving procedurally or through adaptation of the scheme of completion taught. The lowest average score of the second point indicator compared to other points shows that students are less agreed to solve problems (math or not math) using mathematical context or otherwise. In addition to students' preference to solving problems procedurally, a supporting analysis also means that students do not construct formal concepts through a context. Based on this tendency, it is necessary to analyze students' problem-solving skills through the results of the problem test to know their problem-solving skills in more depth.

Students are given a test question based on PISA concerning changes and relationship content, algebraic form material in the next data collection stage. Data analysis based on problem solving capabilities is analyzed using the following rubrics; (1) understanding the problem is indicated by interpreting the condition or problem presented in the question [23], (2) planning the problem solving is indicated by the collection of data and facts and analyzing the information to develop alternative solutions to the solution [22], (3) solving problems according to the plan is shown by utilizing the facts and applying the sequence of the settlement plan [30], (4) re-examining the results of the answers is shown by double-

checking and matching the answer results with the information on the question [24]. Based on the assessment of four indicators of students' ability to solve mathematical problems, students' scores are given in Table 2.

Table 2 Student test results

Indicator	Excellent (%)	Good (%)	Good Enough (%)	Less Good (%)	Bad (%)
Knowledge	0	18.84	11.59	40.57	28.98
Plan	5.79	13.04	28.98	26.08	26.08
Apply	5.79	42.02	23.18	7.24	21.73
Evaluation	2.89	7.24	5.79	62.31	21.73

Based on table 2, it is known that the assessment of students' mathematical problem-solving skills seen from each indicator falls into the category of less good and good. One of the four indicators shows a good category but with a score level that is not very high. Judging from the variety of percentage variations shows that no student interprets the problem into a known form of information; even 28.98% of students do not write at all about the information obtained from the problem. However, 42% of students write down problem-solving steps well, and more than 20% of students are unable to solve the problem presented. Lastly, less than 12% of students re-examined the answer. Figure 1 shows the troubleshooting flow diagram viewed from the indicator.

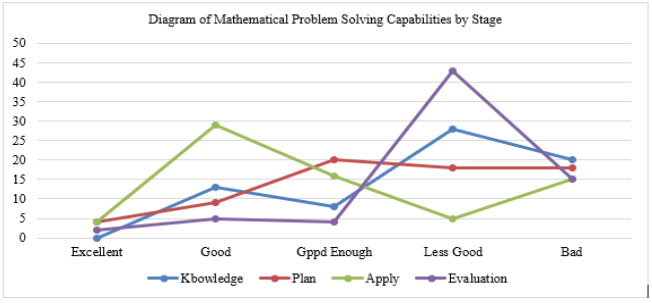

Fig. 1 Mathematical troubleshooting indicators

Figure 1 demonstrates that regarding all the indicators of problem-solving ability, very few students meet the criteria which fall into the category very well. When viewed from a line that shows the application of problem-solving solutions, many students choose to solve the problem without making a plan in advance directly. Most students are already good at applying mathematical concepts to solve problems. Thus, from the provision of test questions to measure the mathematical problem-solving skills of students can be concluded that the student's mathematical problem-solving skills are said to fall into the category of good enough. Furthermore, interviews are conducted to find out and clarify students' mathematical problem-solving skills. Interviews are conducted by asking questions about students' answers to test questions. The results of a structured interview between researchers (P) and research subjects (S) on the issue of typical fabrics of the Gayo Aceh Tribe are shown in Figure 2.

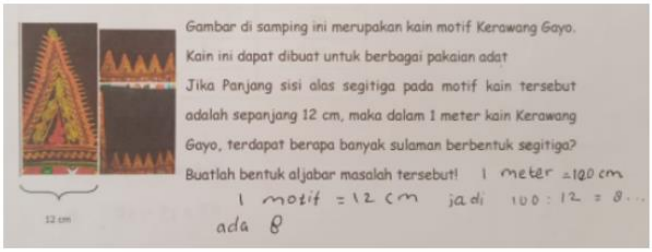

Fig. 2 Subject Answer Type 1 for Item Number 1

P: What does the matter ask about?

S1: About how many triangles for every one meter of Gayo Filigree cloth.

P: Then what strategy do you use to determine how many triangles are there?

S1: Just divide; one meter is equal to 100 centimeters, while the foot (plinth) is 12 centimeters... That means 100 divided by 12 can be 8 comma 3.

P: Why did you only write eight?

S1: Because there cannot be openwork embroidery (*Burdir sulam Kerawang*), loss of yarn, so if you want a full triangle, it is just eight.

The interview results show that students do not interpret the ability to understand problems in written form. However, students directly plan a solution strategy, apply it, and re-examine the answers based on information from the question. In this case, it means that the student is well aware of the problem so that the steps to solve the problem until checking the answer based on the existing information can be solved properly. The same is found in the answer type as figure 3.

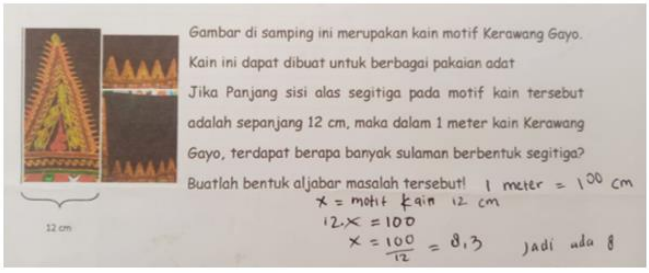

Fig. 3 Subject Answer Type 2 for Item Number 1

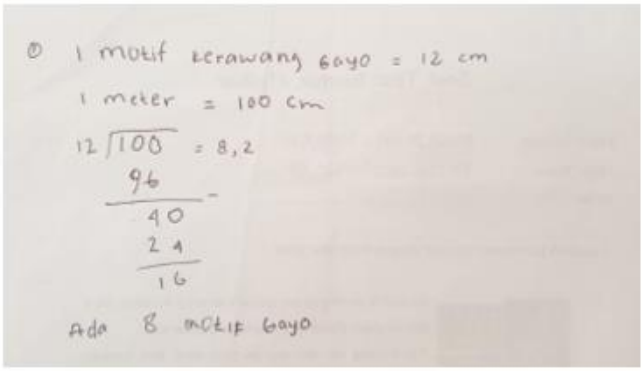

Fig. 4 Subject Answer Type 3 for Item Number 1

Figures 2, 3, and 4 refer to subjects with excellent and good answer categories; the rest of the other study subjects cannot explain well what problems are asked or what are the known things of the problem. This means that students go through the stage of interpreting the problem in writing. However, in fact, they can answer it in simple communication. There are still 28.98% of students who do not know and cannot answer the problem properly because they do not understand the problem and do not know the facts and concepts contained in the problem.

Furthermore, the interview results will be described based on question number two to determine the mindset of students' problem-solving skills, such as Figures 5, 6, and 7.

Fig. 5 Item Number 2

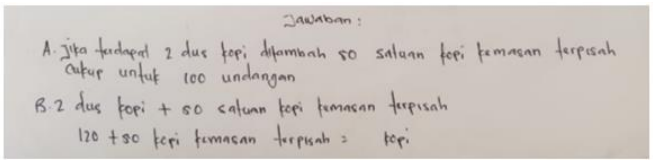

Fig. 6 Subject Answer Type 4 for Question Item Number 2

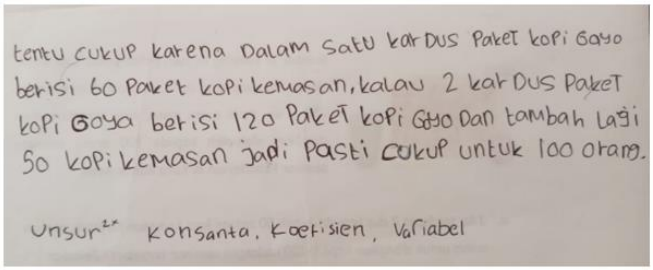

Fig. 7 Subject Answer Type 5 for Question Item Number 2

P: What is the question about?

S5: Is it enough if the two boxes of coffee will be distributed to 100 people? Moreover, plus another 50 separate packs.

P: What is your answer?

S5: Yes, enough ma'am, do not add 50 packs; two boxes alone are enough, more even ...

P: You mean, more how?

S5: Here is ma'am, one box contains 60 packs. If there are two boxes, it means the number is 120... this is only divided for 100 people, that's why I said more... more ma'am could be for 70 more people.

Based on the interview, the result is also not much different from question number one. Students go through stages about interpreting problems in the form of writing. However, judging by how students plan, apply and re-examine the answers by matching the information from the question, students understand the problem well so that they immediately plan a solution and apply it based on the strategy they think. In addition, students are confident that they can account for the results by re-matching the answers based on information from the question.

The third question item shows that students understand patterns and can create them in the form of variables from two different types of observation media. The following will be detailed in the interview results based on the problem as Figures 8 and 9.

P: Do you like eating Aceh noodles?

S6: Yes, ma'am, I like...

P: Well, if from this problem, how to make Aceh noodles?

S6: Cooked ma'am, use seasoning...

P: How many seasonings does it take? If you plan on cooking 5 kg of noodles?

S6: There needs to be a packaged seasoning; there is a fine seasoning (from the cup), ma'am, so each 10 (packs) of packaged seasoning, and 5 bowls of fine seasoning

P: So yes. Then why do you write 20x and 10y?

S6: That's because I suppose... That's to make it easier, for example, the number of packaged spices as much as x.

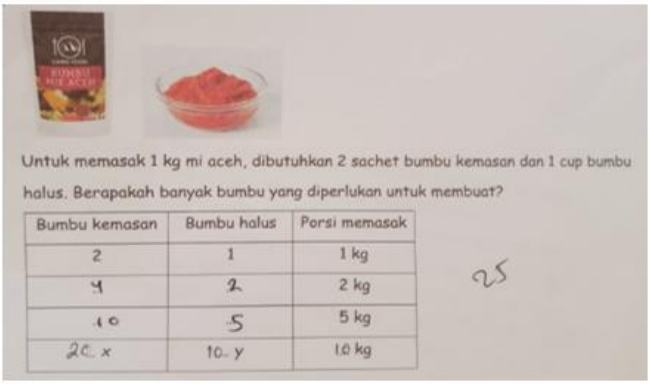

Fig. 8 Subject Answer Type 6 for Item Number 3

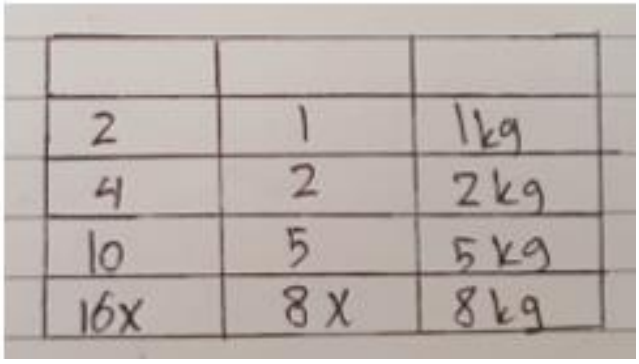

Fig. 9 Subject Answer Type 7 for Item Number 3

The results of the interviews with the students did not mention anything known from the question. Students immediately solve the problem if it is made as much as 5 kilos of noodles. Furthermore, when it comes to variable concepts, students cite it as an example for an observation object, in contrast to subject 7 that does not distinguish the type of variable even though the observation media is different.

Based on the three points above, it is clear that the students tend not to interpret their understanding of problems in writing. However, when interviewed orally, students can explain their understanding of what is asked in the right issue. This is because students are not used to writing down what information is in the problem. Students are used to directly solving problems with their planned strategies. Sometimes the strategy is also only in the student's mind without being poured in the form of writing, so to measure the problem-solving ability must be reviewed orally.

Similarly, rechecking the answers of students who matched it with the information on the problem can only be measured whether or not when interviewed unstructured. Some of the interviewees informed that they checked the problem but did not write it down.

These answers can only be analyzed as falling into the good category. These students are very good at test questions because their answers are quite understandable. Students can communicate and argue well. Students with other categories cannot analyze interview answers because they cannot explain, do not understand what they have written, or do not answer at all the problems given. Thus, it can be concluded that based on the interview results, the mathematical problem-solving skills of the students in this study fall into the category of quite good.

The analysis results showed that students had problem-solving skills with good categories. At the same time, the other two items stated quite good or moderate categories. Thus, it can be concluded that the students' mathematical problem-solving skills are in the category of quite good. This result is in line with the findings of [25] that students in both high, medium, and low disposition categories, have a moderate category of mathematical problem-solving skills. In addition, the study also found that students are not used to solving problems analytically, starting with preparation and planning and rechecking the results of answers. This is also the problem of analysis of students' mathematical problem-solving skills [26]. However, students can immediately solve the problem well and be able to explain the solution strategy in line with the research conducted by [27] on the Wallas model that there is an incubation stage that makes students spend time in making preparations so that students are more likely to solve problems directly.

Based on students' perceptions, students explicitly believe that they have good mathematical problem-solving skills. Perceptually, students tend to believe that they have at least one ability in either category [28] because of their math routine. However, when the test is conducted, no student meets the indicators to understand the problem in written form, and many students do not reflect on the answer results. According to [29], the unusualness of students makes reflection because students do not make preparations in solving problems, so they cannot match the results of the answers with the information available. After an in-depth interview, it was found that only students who had a good and excellent answer could confirm that they had reflected. This finding indicates the fulfillment of communication skills indicators that students who have problem-solving skills can show that they also have a good understanding of the material they are studying. In this case, structured and planned learning activities are very important [30] to support all the abilities that want to be built and become

a goal in the teaching and learning process. Therefore, before the teaching and learning process is carried out, it is expected to make a mature and targeted preparation.

Online learning influences the learning process of research subjects where the subject is a student who graduated from elementary school and entered the junior high school during the pandemic transition period. In those days, students went through the learning period from home with various challenges. During this time, students get online learning patterns so that in the learning process do not get feedback as well as in face-to-face learning patterns. This is quite a negative effect in learning [31], [32], where students encounter limited understanding constraints in mastering materials and communication network problems [33].

This situation affects the development of exclusive functions (EF) in an intensive teaching and learning process. EF skills are skills in learning mathematics that form the basis for developing problem-solving and flexible thinking skills [34]. EF can be formed when students face a new condition where reflectively, there is a desire for students to find a solution, which can happen in intensive meetings.

4. Conclusions

Based on the research results and discussion, it can be concluded about the average mathematical solving ability of junior high school students. Students in solving algebraic problems are categorized in a fairly good or moderate category. Students tend to go through more stages to write down what is understood and the problem-solving strategy plan rather than directly solving the problem. Due to the lack of students making preparations and problem-solving strategy plans, students tend to be unable to make reflection analyses of the results of the answers because they are unable to match the previous data, facts, and information.

However, it is different from students who go through step-by-step problem-solving. The study results will get a deeper picture of the condition of students' mathematical problem-solving skills. Mathematical problem-solving skills are one of the skills that are expected to be developed through mathematics learning. Thus, it is expected that in the teaching and learning process, both teachers and educational observers can always design problems that give rise to students' attitudes to solve problems more than just running problems.

The limitations of face-to-face time inactivity research and the time lag between meetings cause the data collection process to be not as good as the ideal time, where students often forget the problem-solving steps that have been done in the past. With these limitations, the findings obtained in this study show that students' mathematical problem-solving skills can be developed well through a more intensive instructional process. It is expected that the next research will be able to deepen further students' ability to solve problems, especially in the form of problems because there is still the possibility of students having mathematical problem-solving skills that are not poured in oral form.

The novelty of this study is in communication techniques used by students in completing the mathematical tasks. The limitations of this study are due to the implementation of online learning so that students have difficulty in learning mathematics, and they need further research to improve online mathematics learning.

References

[1] INSORIO A. O. and LIBRADA A. R. P. Enhancing Mathematical Critical Thinking and Problem-Solving Skills through Emergenetics® as a Grouping Mechanism. *Contemporary Mathematics and Science Education*, 2(1): 1–10, 2021, doi: 10.30935/conmaths/9289.

[2] AINI N. R., SYAFRIL S., NETRIWATI N., et al. Problem-Based Learning for Critical *Thinking* Skills in Mathematics. *Journal of Physics: Conference Series*, 1155(1): 1–8, 2019, doi: 10.1088/1742-6596/1155/1/012026.

[3] AIN SAFURA N., AISYAH N., HILTRIMARTIN C., and INDARYANTI. Student's mathematical value in mathematics learning using non-routine problem. *Cakrawala Pendidikan*, 37(3): 400–412, 2018, doi: 10.21831/cp.v38i3.19032.

[4] MUSTAFA N., SAID M. N. H. M., ISMAIL Z., and TASIR Z. Mathematical problem solving skills among high achiever students. *Advanced Science Letters* , 23(8): 7494–7498, 2017, doi: 10.1166/asl.2017.9506.

[5] RATNASARI I. P. and NOER S. H. Analysis of Learning Difficulties and Self-Efficacy of Junior High School Students in Solving of Story-Form Mathematics Problems. *Advances in Social Science, Education and Humanities Research*, 253, 405–408, 2019, doi: 10.2991/aes-18.2019.92.

[6] SARI I. K., NASRIADI A., and SALMINA M. Students' understanding of charts: The study of PISA's problem-solving in the content of data. *Journal of Physics: Conference Series*, 1088: 1–7, 2018, doi: 10.1088/1742-6596/1088/1/012108.

[7] ARFIANA A. and WIJAYA A. Problem solving skill of students of senior high schools and Islamic high schools in Tegal Regency in solving the problem of PISA based on Polya's stage. *Jurnal Riset Pendidikan Matematika*, 5(2): 211–222, 2018, doi: 10.21831/jrpm.v5i2.15783.

[8] WILDANI J. The Analysis of Students' Difficulties in Solving PISA Mathematics Problems. *Proceedings of the International Conference on Mathematics and Islam*, 2020(ICMIs 2018): 246–252, doi: 10.5220/0008520202460252.

[9] AHYAN S., TURMUDI, and PRABAWANTO S. Students' Errors in solving the PISA mathematics problem using Newman's error categories. *Journal of Physics: Conference Series.*, 1363(1): 1–7, 2019, doi: 10.1088/1742-6596/1363/1/012088.

[10] OECD, *PISA for Development Assessment and Analytical Framework*. 2017.

[11] THOMSON S., HILLMAN K., and DE BORTOLI, L. *A Teacher's Guide to PISA Mathematical Literacy*. Australia: ACER Press, 2013.
[12] OECD, *PISA 21 Mathematics Framework*. 2018.
[13] RAHMAN M. M. 21st Century Skill 'Problem Solving': Defining the Concept. *Asian Journal of Interdisciplinary Research*, 2(April): 64–74, 2019, doi: 10.34256/ajir1917.
[14] USNUL U., JOHAR R., and SOFYAN H. Potential Effect of PISA Equivalent Questions Using the Context of Aceh Traditional Houses. *Journal of Research and Advances in Mathematics Education*, 4(2): 89–100, 2019, doi: 10.23917/jramathedu.v4i2.8362.
[15] SZABO Z. K., KÖRTESI P., GUNCAGA J., et al. Examples of problem-solving strategies in mathematics education supporting the sustainability of 21st-century skills. *Sustainability*, 12(23): 1–28, 2020, doi: 10.3390/su122310113.
[16] HABIBI H. and SUPARMAN S. Literasi Matematika dalam Menyambut PISA 2021 Berdasarkan Kecakapan Abad 21. *Jurnal Kajian Pendidikan Matematika*, 6(1), 57, 2020, doi: 10.30998/jkpm.v6i1.8177.
[17] LUBIS J. N., PANJAITAN A., SURYA E., and SYAHPUTRA E. 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, 2017.
[18] POLYA, G. How to Solve It: A New Aspect of Mathematical Method. Princeton University Press, 1945. doi: 10.2307/j.ctvc773pk.
[19] MOHAJAN H. K. Two Criteria for Good Measurements in Research: Validity and Reliability. *Annals of Spiru Haret University. Economic Series*, 17(4): 59–82, 2017, doi: 10.26458/1746.
[20] KRIKSCIUNIENE D., SAKALAUSKAS V., and LEWANDOWSKI R. Evaluating the Interdependent Effect for Likert Scale Items. *Lecture Notes in Business Information Processing*, 373 LNBIP(2015): 26–38, 2019, doi: 10.1007/978-3-030-36691-9_3.
[21] DAMA S. Synthetic triangulation as a method of research in social science and humanities. *Zeszyty Naukowe Gdańskiej Szkoły Wyższej*, 2(19): 1–8, 2019.
[22] NCTM Six Principles for School Mathematics. *National Council of Teachers of Mathematics*, 1–6, 2014, [Online]. Available: http://www.nctm.org/uploadedFiles/Math_Standards/12752_exec_pssm.pdf.
[23] UKOBIZABA F., NIZEYIMANA G., and MUKUKA A. Assessment Strategies for Enhancing Students' Mathematical Problem-solving Skills: A Review of Literature. *Eurasia Journal of Mathematic, Science, and Technology Education.*, 17(3): 1–10, 2021, doi: 10.29333/ejmste/9728.
[24] E SALSABILA., RAHAYU W., and DENIYANTI SAMPOERNO P. Performance Assessment to Measure Student's Mathematical Proving Ability Based on the Abductive-Deductive Approach. *KnE Social Sciences*, 2020: 343–354, 2020, doi: 10.18502/kss.v4i14.7892.
[25] GURAT M. G. Mathematical problem-solving strategies among student teachers. *Journal on Efficiency and Responsibility in Education and Science*, 11(3): 53–64, 2018, doi: 10.7160/eriesj.2018.110302.
[26] ASMARA A. S., WALUYA S. B., and ROCHMAD. Analysis of Mathematics Literacy Based on Mathematical Ability. *Jurnal Pendidikan dan Kebudayaan*, 7(2): 135–142, 2017, doi: 10.24246/j.scholaria.2017.v7.i2.p135-142.
[27] MAHARANI H. R., SUKESTIYARNO S., and WALUYA B. Creative Thinking Process Based on Wallas Model in Solving Mathematics Problem. *International Journal on Emerging Mathematics Education*, 1(2) 177, 2017, doi: 10.12928/ijeme.v1i2.5783.
[28] PERMATASARI S. D. A., BUDIYONO, and PRATIWI H. Does gender affect the mathematics creativity of junior high school students? *Journal of Physics: Conference Series*, 1613(1): 1–11, 2020, doi: 10.1088/1742-6596/1613/1/012036.
[29] KALIKY S. H., NURLAELAH E., and JUPRI A. Analysis of mathematical problem solving ability students of junior high school to Polya model. *Journal of Physics: Conference Series*, 1157(4): 8–11, 2019, doi: 10.1088/1742-6596/1157/4/042064.
[30] SARI I. K. Profil Pemecahan Masalah Matematika Siswa usia 14-15 tahun di Banda Aceh. *Numeracy*, 3(1): 73–86, 2016, doi: 10.46244/numeracy.v3i1.203.
[31] CHIRINDA B., NDLOVU M., and SPANGENBERG E. Teaching mathematics during the COVID-19 lockdown in a context of historical disadvantage. *Education Sciences*, 11(4), 2021, doi: 10.3390/educsci11040177.
[32] ALDON G., CUSI A., SCHACHT F., and SWIDAN O. Teaching mathematics in a context of lockdown: A study focused on teachers' praxeologies. *Education Sciences*, 11(2): 1–21, 2021, doi: 10.3390/educsci11020038.
[33] GOLDBERG S. B. *Education in a Pandemic: The Disparate Impacts of COVID-19 on America's Students*. USA: Department of Education, 2021.
[34] STOLTE M., GARCÍA T., VAN LUIT J. E. H., et al. The contribution of executive functions in predicting mathematical creativity in typical elementary school classes: A twofold role for updating. *Journal of Intelligence*, 8(2): 1–20, 2020, doi: 10.3390/jintelligence8020026.

参考文:

[1] INSORIO A. O. 和 LIBRADA A. R. P. 通过 新兴遗传学 ® 作为分组机制增强数学批判性思维和解决问题的技能。当代数学与科学教育，2(1): 1–10, 2021, 土井: 10.30935/conmaths/9289。

[2] AINI N. R., SYAFRIL S., NETRIWATI N. 等。基于问题的数学批判性思维技能学习。物理学杂志：会议系列，1155(1): 1–8, 2019, 土井: 10.1088/1742-6596/1155/1/012026。
[3] AIN SAFURA N., AISYAH N., HILTRIMARTIN C. 和 INDARYANTI。学生在使用非常规问题进行数学学习中的数学价值。教育地平线，37(3)：400–412，2018，土井：10.21831/cp.v38i3.19032。
[4] MUSTAFA N., SAID M. N. H. M., ISMAIL Z. 和 TASIR Z. 高成就学生的数学问题解决能力。 高级科学快报, 23(8): 7494–7498, 2017, 土井: 10.1166/asl.2017.9506。
[5] RATNASARI I. P. 和 NOER S. H. 初中生解决故事式数学题的学习困难和自我效能感分析。社会科学，教育和人文研究进展，253，405–408，2019，土井：10.2991/aes-18.2019.92。
[6] SARI I. K., NASRIADI A. 和 SALMINA M. 学生对图表的理解：PISA 在数据内容中解决问题的研究物理学杂志：会议系列，1088: 1–7，2018，土井：10.1088/1742-6596/1088/1/012108.
[7] ARFIANA A.和 WIJAYA A. 泰戈尔摄政高中和伊斯兰高中学生在解决比萨问题时基于波利亚阶段的问题解决能力。 数学教育研究杂志，5(2): 211–222，2018，土井：10.21831/jrpm.v5i2.15783。
[8] WILDANI J. 学生在解决比萨数学题中的困难分析。2020 年国际数学与伊斯兰教会议论文集（信息管理系统 2018）：246-252，土井：10.5220/0008520202460252。
[9] AHYAN S., TURMUDI 和 PRABAWANTO S. 学生在使用纽曼错误类别解决比萨数学问题时的错误。物理学杂志：会议系列，1363(1): 1–7，2019，土井：10.1088/1742-6596/1363/1/012088.
[10] 经合组织，比萨发展评估和分析框架。 2017。
[11] THOMSON S., HILLMAN K. 和 DE BORTOLI, L. 比萨数学素**养**教师指南。澳大利亚：宏碁出版社，2013 年。
[12] 经合组织，比萨 21 数学框架。 2018 年。
[13] RAHMAN M. M. 21 世纪技能“解决问题”：定义概念。亚洲跨学科研究杂志，2（四月）：64–74，2019，土井：10.34256/ajir1917。
[14] USNUL U., JOHAR R. 和 SOFYAN H. PISA 等效问题在亚齐传统房屋背景下的潜在影**响**。数学教育研究与进展杂志，4(2)：89–100，2019，土井：10.23917/jramathedu.v4i2.8362。
[15] SZABO Z. K., KÖRTESI P., GUNCAGA J. 等。数学教育中支持 21 世纪技能可持续性的问题解决策略示例。可持续性，12(23)：1–28，2020，土井：10.3390/su122310113。
[16] HABIBI H. 和 SUPARMAN S. 基于 21 世纪技能的欢迎比萨 2021 的数学素**养**. 数学教育研究杂志, 6(1), 57, 2020, 土井: 10.30998/jkpm.v6i1.8177.
[17] LUBIS J. N., PANJAITAN A., SURYA E. 和 SYAHPUTRA E. VIII-2 级初中上纳闽巴都刀片学生数学问题解决能力的分析。国际教育与学习小说研究杂志，4(2): 131–137, 2017。
[18] POLYA, G. 如何解决它：数学方法的一个新方面。普林斯顿大学出版社，1945。土井：10.2307/j.ctvc773pk。
[19] MOHAJAN H. K. 研究中良好测量的**两**个标准：有效性和可靠性。螺旋哈雷特大学年鉴。经济系列, 17(4): 59–82, 2017, 土井: 10.26458/1746。
[20] KRIKSCIUNIENE D., SAKALAUSKAS V. 和 LEWANDOWSKI R. 评估李克特量表项目的相互依赖效应。商业信息处理讲义, 373 国家知识产权局(2015): 26–38, 2019, 土井: 10.1007/978-3-030-36691-9_3。
[21] DAMA S. 合成三角测量作为一**种**社会科学和人文研究方法。 格但斯克大学科学期刊, 2(19): 1–8, 2019。
[22] NCTM 学校数学六项原则。全国数学教师委员会，2014 年 1-6 日，[在线]。可用：http://www.nctm.org/uploadedFiles/Math_Standards/12752_exec_pssm.pdf。
[23] UKOBIZABA F., NIZEYIMANA G. 和 MUKUKA A. 提高学生数学问题解决能力的评估策略：文献综述。 欧亚数学，科学和技术教育杂志，17(3): 1–10，2021，土井：10.29333/ejmste/9728。
[24] E SALSABILA., RAHAYU W., 和 DENIYANTI SAMPOERNO P. 基于溯因-演绎法衡量学生数学证明能力的表现评估。克恩社会科学，2020: 343–354, 2020, 土井: 10.14ks.185 .7892。
[25] GURAT M. G. 学生教师的数学问题解决策略. 教育与科学效率与责任杂志，11(3): 53–64，2018，土井：10.7160/eriesj.2018.110302.
[26] ASMARA A. S., WALUYA S. B. 和 ROCHMAD。基于数学能力的数学素**养**分析。教育与文化杂志，7(2): 135–142, 2017, 土井: 10.24246/j.scholaria.2017.v7.i2.p135-142。
[27] MAHARANI H. R., SUKESTIYARNO S., 和 WALUYA B. 基于瓦拉斯模型解决数学问题的创造性思维过程。国际新兴数学教育杂志，1(2) 177，2017，土井：10.12928/ijeme.v1i2.5783。
[28] PERMATASARI S. D. A., BUDIONO, 和 PRATIWI H. 性别是否会影**响**初中生的数学创造力？ 物理学杂志：会议系列，1613(1): 1–11，2020，土井：10.1088/1742-6596/1613/1/012036。

[29] KALIKY S. H., NURLAELAH E., 和 JUPRI A. 初中生数学解题能力对波利亚模型的分析。 物理学杂志：会议系列 1157(4): 8–11, 2019, 土井：10.1088/1742-6596/1157/4/042064。

[30] SARI I. K. 班达亚齐数学学院 14-15 岁学生数学问题解决简介，3(1): 73–86, 2016, 土井：10.46244/numeracy.v3i1.203。

[31] CHIRINDA B., NDLOVU M. 和 SPANGENBERG E. 在新冠肺炎封锁期间在历史劣势背景下教授数学。教育科学, 11(4), 2021, 土井: 10.3390/educsci11040177。

[32] ALDON G., CUSI A., SCHACHT F. 和 SWIDAN O. 在锁定环境下教授数学：一项关注教师行为学的研究。教育科学, 11(2): 1–21, 2021, 土井: 10.3390/educsci11020038。

[33] GOLDBERG S. B. 大流行中的教育：新冠肺炎对美国学生的不同影响。美国：教育部，2021。

[34] STOLTE M., GARCÍA T., VAN LUIT J. E. H., 等。执行功能在预测典型小学课堂数学创造力中的贡献：更新的双重作用。情报杂志，8(2): 1–20, 2020, 土井：10.3390/jintelligence8020026。