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Students' Mathematical Problem-Solving Ability Reviewed from Adversity Quotient in STEM-Integrated Challenge-Based Learning

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Abstract

This study aims to analyze the quality of learning with the STEM-integrated Challenge Based Learning (CBL) model on students' mathematical problem-solving abilities, and describe students' mathematical problem-solving abilities in terms of Adversity Quotient (AQ). This mixed methods study uses the sequential explanation method, through quantitative research to obtain data on mathematical problem-solving abilities and in qualitative research to obtain descriptive data on problem-solving abilities in terms of AQ. Data collection was carried out through mathematical problem-solving ability tests, observations, and interviews. The study was conducted at Ky Ageng Giri Junior High School in the 2023/2024 academic year with samples of class VIII B as the experimental group and VIII D as the control group. The data obtained were analyzed through parametric tests and described for review from AQ. The results of the study indicate that the implementation of the STEM-integrated CBL model is of high quality with details of learning devices categorized as valid, learning implementation categorized as very good, and STEM-integrated Challenge Based Learning learning is effective on students' mathematical problem-solving abilities. Furthermore, analysis based on AQ shows significant differences in ability in the problem-solving process. Climber students demonstrated excellent mastery of all stages of problem-solving, from understanding the problem, planning the solution, implementing the solution, and re-examining the results. Camper students were able to understand the problem and plan well and provide adequate solutions, although they were still less than optimal in the re-examining stage. Meanwhile, quitter students were only able to understand the problem fairly well, but experienced difficulties in the planning, solution implementation, and re-examining stages of the solutions they had created.

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INTRODUCTION

Mathematical problem-solving skills are one of the skills students are expected to possess in this century. When applied in the learning process, they can help students expand their knowledge, solve new problems, and adapt to new situations (Griffin & Care, 2014). This aligns with the research findings of Wijayanti et al. (2018) that mathematical problem-solving skills are essential for students. The National Research Council (2012) also stated that when applied in learning, these skills will help students acquire new knowledge, solve new problems, and adapt to new situations. Problem-solving skills are high-level mathematical thinking skills that require significant effort to develop (Nugraheni et al., 2014). Students who possess these skills can easily identify available information, search for relevant information, set learning goals, and apply what they know when they receive information (Bellanca, 2010; Griffin & Care, 2014).

Based on preliminary studies, it was found that students' mathematical problem-solving skills at the research site were still relatively low. This can be seen from the results of the daily mathematics test, where in the following problem, students were asked to determine the area of a rectangular rice field by applying the concept of algebraic multiplication as seen in Figure 1.

Pak Andi memiliki sawah yang berbentuk persegi panjang dengan panjang $(4x + 2)$ cm dan lebar $(2x + 1)$ cm. Berapakah luas sawah pak Andi?

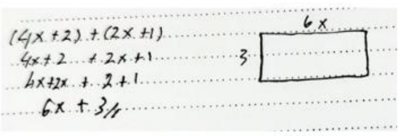

Figure 1. Student Work Results

Based on the results of the students' work, it was also found that these students were not optimal in all problem-solving indicators. They were not optimal in identifying problems, planning problems, and determining the appropriate solution steps and completing them to obtain the correct answer. This finding is supported by test results conducted by teachers in four classes, which obtained an average score of 53.67 on a maximum scale of 100, with 15% of students achieving the completion criteria. One method that can be used to improve mathematical problem-solving skills is to integrate unconventional approaches that capture students' attention and focus (Bahri et al., 2018), one of which is the challenge-based learning model.

The Challenge-Based Learning (CBL) model enables students to actively engage in contextual problem-solving activities related to everyday life. This model allows students to choose, create their own learning paths, and carry out the problem-solving process to achieve desired outcomes (Pérez-Sánchez et al., 2020). This plays a crucial role in enhancing students' problem-solving creativity (Pepin & Kock, 2021). This aligns with the research findings of Nieto-Jalil et al. (2023), which demonstrated that challenge-based learning is an appropriate model for improving students' mathematical problem-solving abilities.

Science, Technology, Engineering, and Mathematics (STEM) is a learning approach that combines mathematics, science, engineering, and technology as a whole, with integrated and coordinated instruction through the resolution of real-world problems (Martín-Páez et al., 2019). The application of STEM in mathematics learning can help students solve everyday mathematical problems, train them in scientific thinking, and use technology to receive and process the information they receive (Milaturrahmah et al., 2017). These findings align with research by Şahin (2021), which found that integrated STEM learning, where each discipline complements the others, can influence and enhance students' mathematical problem-solving abilities.

McDonough & Sullivan (2014) argue that exploration of affective and cognitive aspects is essential because both influence mathematics learning. Given the urgency of developing these two aspects, teachers, as facilitators, must pay attention to students' cognitive and affective aspects, as both are crucial. Adversity Quotient (AQ), a measure of challenge-responsiveness, is one factor that must be considered in measuring a student's success in mathematics learning (Stoltz, 2000). AQ plays a crucial role in students' lives in facing challenges (Parvathy & Praseeda, 2014). Research by Damiles et al. (2022) shows that AQ can impact students' mathematical problem-solving abilities, particularly in mathematics learning. Furthermore, they found that students with higher AQs had better mathematical problem-solving abilities.

Based on the background described above, research is needed on mathematical problem-solving abilities, reviewed from the perspective of students' Adversity Quotient in the STEM-integrated Challenge-Based Learning model. The purpose of this study is to analyze the quality of learning with the STEM-integrated Challenge Based Learning model on students' mathematical problem-solving abilities, and to describe students' mathematical problem-solving abilities in terms of Adversity Quotient.

METHOD

This mixed methods research uses the sequential explanatory method. This method combines quantitative and qualitative research sequentially, with quantitative research conducted first and then qualitative research (Sugiyono, 2019). Through quantitative research, data on students' mathematical problem-solving abilities and AQ levels will be obtained, which will be analyzed to test the research hypothesis. Meanwhile, in this qualitative research, data related to the description of students' problem-solving abilities, viewed from AQ, will also be obtained. Data collection was carried out through mathematical problem-solving ability tests, AQ questionnaires, observations, and interviews. The data obtained were analyzed through parametric tests and described in terms of AQ. The population in this study was all eighth-grade students of Ky Ageng Giri Middle School in the 2023/2024 academic year, with samples of class VIII B as the experimental group and VIII D as the control group.

RESULTS AND DISCUSSIONS

The research findings in this study are divided into two sections based on the problem formulation. These two sections cover (1) the quality of learning using the STEM-integrated challenge-based learning model and (2) a description of students' problem-solving abilities in terms of adversity quotient.

Learning quality in this study is defined as an assessment of the validity (planning), practicality (implementation), and effectiveness (evaluation) stages (Nieveen, 1999). Assessment at the planning stage is conducted through validation of learning tools, at the implementation stage through assessment of learning implementation, and at the evaluation stage through testing of learning effectiveness.

During the learning planning stage, an assessment is conducted on the mathematics learning tools used in the STEM-integrated challenge-based learning model to assess students' problem-solving abilities. This assessment includes validation of the Learning Objective Flow (ATP) and the developed Learning Module. Validation was conducted using a validation sheet provided by the researcher and validated by two experts and one practitioner. Table 1 shows the validation results of the Learning Objective Flow in the STEM-integrated challenge-based learning model.

Tabel 1. ATP Validation Results

Validator Code	Result	Average	Category
V01	5.00	4.62	Very Good
V02	4.86		
V03	4.00		

Based on the results in Table 1, each validator gave a very good rating. The average validation score for the learning objectives flow was 4.62, categorized as very good. Based on the learning tool assessment criteria, it was concluded that the learning objectives flow was valid.

The imperfect results may be due to deficiencies in several aspects, such as language clarity and ease of understanding. These deficiencies can be attributed to language that may be too formal and complex. A good ATP should prioritize clarity and ease of understanding, as they are important guidelines for educators in planning learning activities. This aligns with Sugiharto & Sitinjak (2006), who stated that the use of technical terms or excessively long sentences without additional explanation can reduce clarity. Learning tools must be designed with teacher and student understanding in mind. If the language is too abstract or non-contextual, its effectiveness is reduced (Cholid et al., 2024). A less than perfect score for language clarity in the ATP can impact its implementation in classroom learning activities. A mismatch between learning objectives and implementation can occur if teachers do not clearly understand the expectations of the ATP. This aligns with research by Sutrisno et al. (2023) also showed that when teachers provided explanations in language that was difficult to understand, students showed signs of being less enthusiastic. Table 2 shows the results of the validation of the teaching module in the STEM-integrated challenge-based learning model.

Tabel 2. Teaching Module Validation Results

Validator Code	Result	Average	Category
V01	5.00	4.69	Very Good
V02	4.77		
V03	4.26		

Based on the results in Table 2, two validators gave a rating of "very good" and one gave a rating of "good." The final average validation score for the teaching module was 4.69, categorized as "very good." Based on the learning tool assessment criteria, it can be concluded that the developed teaching module is valid.

The imperfect results may be due to deficiencies in several aspects, such as the writing sequence of the teaching module components in the "Merdeka Curriculum". The imperfect sequence of the teaching module components in the "Merdeka Curriculum" can be caused by inconsistencies in the phase sequence and the lack of systematic writing of the teaching module. This impacts learning implementation difficulties due to the unstructured flow of the teaching module (Yuhaga, 2023). A study by Salsabilla et al. (2023) showed that writing teaching modules that do not align with the curriculum structure has the potential to reduce the impact of meaningful learning. Yuhaga (2023) also confirmed that incorrect sequencing is a common problem that can be corrected through ongoing guidance.

Based on the validation results of the learning objectives and learning modules, it was found that, despite some shortcomings, the learning tools were valid and could foster students' mathematical problem-solving abilities.

During the learning implementation phase, assessment was conducted through observations of teacher and student activities during mathematics lessons using the STEM-integrated challenge-based learning model. Observations were conducted throughout the lesson using assessment guidelines on the observation sheet.

Tabel 3. Observation Results of Teacher Activities and Student Activities

Activity	Observation Results Meeting					Average	Category
	1	2	3	4	5		
Teacher	88.33%	85.00%	89.17%	88.33%	91.67%	88.50%	Very Good
Students	81.11%	82.22%	84.44%	82.22%	86.67%	83.33%	Very Active

Table 3 shows the results of observations of teacher and student activities in mathematics learning using the STEM-integrated challenge-based learning model. The average teacher and student activity levels were 88.50% and 83.33%, respectively, categorized as very good.

The less-than-perfect results may be due to deficiencies in several aspects, such as how teachers conduct formative assessments and how students respond to peer discussions. The lack of optimal teacher formative assessment performance may be due to time constraints and a lack of understanding of formative assessment techniques. Özkan & OZKAN (2025) stated that teachers can experience difficulties providing detailed feedback to all students due to large student numbers and busy schedules. The variety of formative assessment techniques can also lead to teachers not fully understanding and implementing them (Enu, 2021). This results in students not receiving enough specific feedback to correct errors, and teachers may miss opportunities to adapt teaching methods to the most recent student data (Enu, 2021; Trujillo et al., 2025). Suboptimal student feedback on peer discussions may be due to students' lack of skills in delivering feedback and arguments. Calkins et al. (2020) support the idea that the feedback process requires students to critically evaluate mathematical arguments and provide constructive feedback; this process increases students' awareness of their role in collaborative learning. Involvement in providing feedback increases students' sense of responsibility for the learning process and strengthens their role as active learners (Söderström & Palm, 2024).

In the learning evaluation stage, assessment is conducted by assessing the effectiveness of mathematics learning using the STEM-integrated challenge-based learning model. Learning is said to be effective if (a) the average mathematical problem-solving ability of students in learning with the STEM-integrated challenge-based learning model reaches the learning objective completion criteria, namely 70, (b) the proportion of mathematical problem-solving ability completion in learning with the STEM-integrated challenge-based learning model reaches more than 75%, (c) the average mathematical problem-solving ability of students in learning with the STEM-integrated challenge-based learning model is more than the average mathematical problem-solving ability of students in learning with the problem-based learning model, and (d) the proportion of mathematical problem-solving ability completion in learning with the STEM-integrated challenge-based learning model is higher than the proportion of mathematical problem-solving ability completion in learning with the problem-based learning model.

Based on the testing conducted, the average mathematical problem-solving ability of students in the STEM-integrated challenge-based learning model was above 70. These results indicate that the integration of CBL and STEM enables students to address contextual problems, practice collaboration, and apply mathematical concepts in real-world situations. This aligns with research by Dinasari & Ardiansyah (2023), which states that CBL-STEM improves problem-solving skills through a multidisciplinary approach. Research by Johnson & Adams (2011) found that 90% of teachers experienced improved problem-solving skills after implementing the CBL model. Ngiamsunthorn (2020) also confirmed that CBL strengthens students' creative thinking in solving complex problems. Research by Utami et al. (2018) also found that STEM learning can improve students' problem-solving abilities by 80.86%. Based on these research results and the opinions of several experts, it can be concluded that the innovative STEM-integrated CBL model significantly improves students' average mathematical problem-solving abilities.

The second test revealed that the proportion of students' mathematical problem-solving abilities in the STEM-integrated challenge-based learning model met the learning objective achievement criteria, exceeding 75%. This finding aligns with research by Fairazatunnisa et al. (2021), which demonstrated that CBL learning has been shown to improve classical mathematical problem-solving abilities. Sumarni & Kadarwati (2020) also confirmed that STEM integration in learning significantly improves higher-level mathematics abilities and encourages more students to achieve learning mastery. Based on these research findings and the opinions of several experts, it can be concluded that the STEM-integrated CBL innovation model significantly increases the proportion of students achieving mathematical problem-solving abilities.

The third test revealed that the average mathematical problem-solving ability of students in the STEM-integrated challenge-based learning model exceeded the average mathematical problem-solving ability of students in conventional learning. Rizky & Ardiansyah (2023) stated that the STEM-integrated CBL syntax requires students to solve real-world challenges. This will increase independence, collaboration, and active participation in learning. It was also found to improve higher-order problem-solving skills. CBL-STEM integration has also been shown to improve students' overall higher-order thinking skills, making learning more contextual and relevant to 21st-century needs (Wulandari et al., 2023). Based on the research results and the opinions of several experts, it can be concluded that the average mathematical problem-solving ability of students in the STEM-integrated Challenge-Based Learning model is higher than the average mathematical problem-solving ability of students in the Problem-Based Learning model.

The final test showed that the proportion of students completing the STEM-integrated Challenge-Based Learning model was higher than the proportion of students completing the conventional learning model. Research by Ardiansyah & Asikin (2020) and Fairazatunnisa et al. (2021) demonstrated that CBL-based learning integrated with STEM can improve mathematical problem-solving skills and the proportion of students who complete mathematics learning. Kurniawati et al. (2019) demonstrated that the CBL model can support 21st-century development by positively influencing students' mathematical problem-solving abilities. The integration of CBL with STEM also produces meaningful results and improves mathematical concept understanding and mathematical problem-solving abilities (Hutauruk & Ardiansyah, 2024)

Based on these results, it was found that the planning stage obtained valid STEM-integrated Challenge Based Learning learning tools. The implementation stage obtained excellent and very active STEM-integrated Challenge Based Learning learning implementation. The evaluation stage obtained the effectiveness of STEM-integrated Challenge Based Learning mathematics learning on students' mathematical problem-solving abilities. It can be concluded that STEM-integrated Challenge Based Learning learning has a high quality impact on students' mathematical problem-solving abilities.

Based on the results of the AQ questionnaire, it was found that of the 32 students who participated, 6 were climbers, 22 were campers, and 4 were quitters. Furthermore, using purposive sampling, two subjects were selected to represent each group. The description of students' mathematical problem-solving abilities in terms of their adversity quotient was carried out by analyzing test results and interviews conducted with selected research subjects.

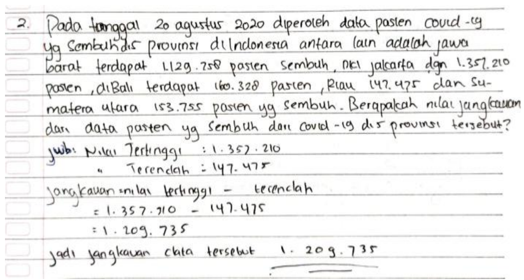
2. Pada tanggal 20 agustus 2020 diperoleh data pasien covid-19 yg sembuh di 5 provinsi di Indonesia antara lain adalah jawa barat terdapat 1.129.258 pasien sembuh, DKI jakarta dgn 1.357.210 pasien, di Bali terdapat 160.328 pasien, Riau 147.475 dan Sumatera utara 153.755 pasien yg sembuh. Berapakah nilai jangkauan dari data pasien yg sembuh dari covid-19 di 5 provinsi tersebut?
jwb: Nilai Tertinggi : 1.357.210
" Terendah : 147.475
Jangkauan = nilai tertinggi - terendah
= 1.357.210 - 147.475
= 1.209.735
Jadi jangkauan data tersebut 1.209.735

Figure 2. Climber 1 Student Work Results

Based on Figure 2, it was found that subject CL1 was able to formulate the correct steps and use formulas to find the range of values very well. He possessed good mathematical operation skills and was able to use information appropriately to obtain correct answers. Subject CL1 was also able to present appropriate reasons to support his conclusions. The test results indicated that subject CL1 was able to meet all four indicators of mathematical problem-solving ability, including the ability to correctly locate and cite known and requested information, the ability to plan the problem well, the ability to solve the problem according to the plan, and the ability to double-check the answers obtained. In this regard, the following is the result of an interview with subject climber 1.

Q: "What information did you obtain from this problem?"

CL1: "In question number 2, I obtained information regarding data on recovered Covid-19 patients in five provinces in Indonesia. West Java has 1,129,258 patients, Jakarta has 1,57,210 patients, Bali has 160,328 patients, Riau has 147,475 patients, and North Sumatra has 153,755 recovered patients."

Q: "What is the question asking?"

CL1: "What is the question asking for is the range value of the recovered patient data, ma'am."

Q: "To solve this problem, what concept did you use and what steps did you take?"

CL1: "Using the range concept, ma'am, first I found the highest and lowest recovered patient data, then subtracted the highest data from the lowest data."

Q: "Are you sure your answer is correct?"

CL1: "Yes, ma'am."

Q: "What is the conclusion of your solution, and provide a reason, and did you conduct a re-examination?"

CL1: "So, the data range I calculated, or the range of recovered patients in the five known provinces, is 1,209,735. This is consistent with my calculations, and I've also double-checked my answer, ma'am."

The interview with subject CL1 showed that subject CL1 completed the problem well. Subject CL1 was able to correctly identify known and requested information, planned the problem well, and solved the problem according to the plan, resulting in the correct answer. Subject CL1 also drew conclusions from the answers obtained and double-checked them.

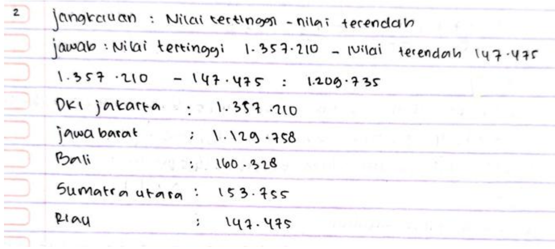

Figure 3. Climber 2 Student Work Results

Based on Figure 3, subject CL2 demonstrated good problem-solving skills, as evidenced by her ability to accurately identify existing information and questions posed in the problem. Subject CL2 was able to formulate appropriate steps and use formulas to find range values very well. She possessed excellent mathematical operation skills and was able to use information appropriately to obtain correct answers. However, subject CL2 failed to present conclusions based on her calculations. The test results indicated that subject CL2 met three indicators of mathematical problem-solving ability: the ability to correctly identify and articulate known and requested information, the ability to plan the problem effectively, and the ability to solve the problem according to plan. In this regard, the following is an interview with subject climber 2:

P: "What information did you obtain from this problem?"

CL2: "In this question, I received general information regarding Covid-19 and how to treat Covid-19 patients. I also obtained data on patients who have recovered from Covid-19 in five provinces in Indonesia. In West Java, there are 1,129,758 recovered patients, in Jakarta, there are 1,357,210 recovered patients, in Bali, there are 160,328 recovered patients, in Riau, there are 147,475 recovered patients, and in North Sumatra, there are 153,755 recovered patients from Covid-19."

P: "What is the question asking?"

CL2: "It asks for the range value of the data on patients who have recovered from Covid-19."

P: "To solve this problem, what concept did you use and what steps did you take?"

CL2: "Here, I used the range concept or formula, ma'am. So, I first found the highest and lowest data for recovered patients, then subtracted the highest data from the lowest data."
P: "Are you sure your answer is correct?"
CL2: "Are you sure, ma'am?"
P: "What is the conclusion of your solution, and why didn't you write it on your answer sheet? Did you double-check it?"
CL2: "So, the range value of the data on recovered COVID-19 patients in five provinces, namely DKI Jakarta, West Java, Bali, North Sumatra, and Riau, is 1,209,735. I apologize for the conclusion, ma'am, because I'm afraid, I don't have enough time. I've also double-checked my answer."

The interview with subject CL1 showed that subject CL2 was able to correctly identify known and asked information, planned the problem well, and solved the problem according to the plan, resulting in the correct answer. Subject CL2 was also able to draw a good conclusion from her answer, although she missed the opportunity to write it on her answer sheet due to being in a hurry and fearing time constraints. Subject CL2 also double-checked her answer.

Based on the test and interview results for Climber 1 and Climber 2, it was found that Climber students were able to fulfill all four indicators of mathematical problem-solving ability: understanding the problem, planning the solution, implementing the problem-solving plan, and reviewing it. This is consistent with research by Izzati & Utami (2024) that found that students with high AQ, or Climbers, tend to be optimistic, innovative, and responsible in solving mathematical problems, thus better able to fulfill the problem-solving indicators comprehensively. Research by Lestari et al. (2022) also showed that students with Climber AQ were able to complete all stages of mathematical problem-solving due to their high fighting spirit and ability to systematically overcome challenges. Students with high AQ are motivated to be active, responsible with assignments, and persistent in facing challenges.

The analysis of the problem-solving ability of Camper students was conducted using the same method as for Climber students, namely by selecting two subjects representing the Camper type. The test results were then analyzed, followed by verification through interviews, and concluded with triangulation. Based on the analysis of the two camper subjects, conclusions can be drawn regarding the problem-solving abilities of camper students.

Test and interview results from Camper 1 and Camper 2 subjects indicate that camper subjects mastered three indicators of mathematical problem-solving ability: understanding the problem, planning the solution, and implementing the problem-solving plan. However, the indicator of reviewing problem-solving results was not yet mastered. This aligns with research conducted by Baharullah et al. (2022) that found that camper students were able to understand the problem, plan, and implement the problem-solving plan, but were still weak in reviewing their solutions. This is because camper students tended to be less thorough in evaluating their results and were more quickly satisfied with the solutions they had found. Septianingtyas & Jusra (2020) also stated that camper students were able to complete the initial stages of problem-solving but were unable to reflect on or evaluate their results.

The analysis of the problem-solving abilities of quitter subjects was conducted using the same method as for climber subjects: analyzing the test results of the two subjects representing quitters, followed by verification through interviews, and concluded with triangulation.

The test and interview results of Quitter Subject 1 and Quitter Subject 2 showed that the mathematical problem-solving ability indicator was understanding the problem. Meanwhile, the other three indicators, such as planning the problem-solving, implementing the problem-solving plan, and reviewing the results of the problem-solving, had not been mastered. This is consistent with research conducted by Supriadi et al. (2021), which found that students with the quitter type tended to be unable to determine sufficient and necessary conditions for understanding a problem, were unable to formulate a plan, were unable to solve problems with the correct steps, and did not review their answers. This is supported by Asmana & Nugroho (2023), who found that students with the quitter type tended to be unable to meet all indicators of mathematical problem-solving. They tended to have only a limited understanding of the problem, did not plan or implement a solution strategy, and did not check their answers

CONCLUSION

The results of the study indicate that the learning tools using the STEM-integrated Challenge-Based Learning model are of high quality. The developed learning tools are categorized as very good and valid, the learning implementation is categorized as very good, and the STEM-integrated Challenge-Based Learning is effective in improving students' mathematical problem-solving abilities.

A description of students' mathematical problem-solving abilities, as measured by their Adversity Quotient, was also obtained. Climber students were able to understand the problem well, identify known and questionable information, develop a sound problem-solving plan, and solve the problem based on the plan to obtain correct results. They were also able to double-check their answers. Therefore, climber students were able to meet four indicators of mathematical problem-solving ability. Camper students were able to understand the problem well, identify known and questionable information in the problem, develop an accurate problem-solving plan, determine the formula to be used to solve the problem, and implement the problem-solving process according to their plan. However, camper students were not yet able to double-check their answers. Based on the description, it was found that camper students have quite good problem-solving skills and are able to meet three indicators of mathematical problem-solving ability. Quitter students may be less able to solve the problems given, they tend to give up halfway and do not complete the problem to the end. Quitter students can understand the problem quite well, they can determine the information known and asked in the problem quite well. However, quitter students have not been able to formulate a proper problem-solving plan, have not been able to determine the formula to be used to solve the problem correctly, have not been able to implement the problem-solving according to the plan they have made, and do not double-check the answers obtained. Based on the description, it was found that quitter students have poor problem-solving skills and are only able to meet one indicator of mathematical problem-solving ability.

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