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Reversible Thinking in Mathematical Problem Solving: An Adversity Quotient-Based Analysis of Grade VIII Students

Mar' Atus Shalehah[1], Yantoro[2], Rohati[3]
[1,2,3]University of Jambi, Jambi, Indonesia

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ABSTRACT

Reversible thinking is the ability to reverse the order of thinking, understand two-way relationships, and logically and reflectively retrace initial information. This study aimed to describe students' reversible thinking abilities in mathematical problem solving based on adversity (AQ). The research was conducted using a qualitative descriptive design with 21 eighth-grade students of MTs Annajah Sungai Luar. From these, five subjects were selected purposively to represent the AQ types: quitter, camper, and climber. Data were collected through AQ questionnaires, Test of Reversible Thinking (TTR) essay tasks, and interviews. The results indicated that students with the quitter type were unable to fulfill all aspects of reversible thinking. Camper-type students could fulfill two aspects, namely negation and reciprocity, while climber-type students were able to fulfill all three aspects: negation, reciprocity, and returning to the initial condition. The findings suggest that students with higher AQ demonstrate stronger reversible thinking skills in mathematical problem solving. This contributes to mathematics education by emphasizing the importance of fostering reflective thinking and resilience in the learning process.

Corresponding Author:

Rohati
Faculty of Teacher Training and Education, Mathematics Education, University of Jambi
Email: rohati.fkip@unja.ac.id

1. INTRODUCTION

The thinking process is a necessary step in generating ideas and determining how to solve problems [1]. Thinking is not only processing information mentally or cognitively, which includes the steps of discovering, analyzing, creating, reflecting, and arguing, but also requires higher-order thinking skills that go beyond simply remembering, restating, or referring without processing, but rather involves thinking processes related to critical thinking, creativity, problem solving, and decision making [2]. Problem-solving is related to the thinking process. According to the NCTM, problem-solving is a key tool in the learning process [3]. It is a process of solving previously unknown problems through assignments, where students are required to develop ideas to build new knowledge and develop mathematical skills. In reality, problem-solving skills remain a challenge for most students, as evidenced by the low levels of problem-solving skills observed at various educational levels and in diverse mathematical contexts [4], [5].

One important cognitive strategy in problem-solving is the ability to think backward [6], [7], [8]. Piaget introduced this as reversible thinking, which refers to the mental ability to reverse the order of thought back to its starting point [9], [10]. Reversible thinking enables students to solve problems by reasoning in both forward and backward directions, developing strategies from the final result to the initial condition, and minimizing errors in decision making [11], [12], [13]. Despite its importance, previous research shows that students' reversible thinking abilities are still relatively low, from elementary school to university levels [14], [15]. Students also tend to struggle when faced with variations of problems, even within the same context, and often fail to verify the correctness of their solutions.

Although some researchers, such as Aura Pebrianti [12] and Lamon [16], note the lack of studies on reversible thinking in mathematics education, most existing works tend to emphasize other influencing factors of problem solving, such as Intelligence Quotient (IQ), Emotional Quotient (EQ), and Spiritual Quotient (SQ). In contrast, relatively few studies examine the role of Adversity Quotient (AQ). AQ, introduced by Stoltz, measures an individual's ability to endure challenges and persist in the face of obstacles [22]. Unlike IQ or EQ, AQ highlights resilience, motivation, and persistence, which are crucial for success in mathematics learning [19], [20], [21]. Prior studies also indicate a positive correlation between AQ and problem-solving performance [23], [24]. Thus, exploring reversible thinking from the perspective of AQ offers a new and meaningful contribution to the field.

In mathematics, many topics, particularly statistics, require reversible thinking, as decision-making often involves analyzing data from different perspectives to minimize errors [25], [26], [27]. However, there is still limited research that integrates reversible thinking and AQ in the context of mathematics education, especially in statistics at the junior high school level. This study seeks to fill this gap by analyzing eighth-grade students' reversible thinking abilities in solving statistical problems based on their AQ type.

Research Question: How do students with different Adversity Quotient (AQ) types (quitters, campers, and climbers) demonstrate reversible thinking abilities in solving mathematical problems?

2. METHOD

This study employed a qualitative approach to comprehensively understand the phenomena experienced by the research subjects, such as behavior, perceptions, motivations, and actions, and to describe them in specific language and natural contexts [28]. The research process consisted of several stages: preparation, implementation, analysis, and conclusion drawing.

At the preparation stage, theories on reversible thinking were reviewed, instruments were developed, and expert validators conducted validation. This study adopted the reversible thinking indicators developed by Maf'ulah et al. [29] and Fadrik Adi et al. [23] to analyze students' abilities to solve Reversible Thinking Test (RTT) questions in mathematical problem-solving. The forward process was defined as creating a new equation equivalent to the initial equation, whereas the backward process was defined as returning the equation to its original form. Table 1 presents the reversible thinking indicators used in this study.

Table 1. Reversible thinking indicators

Reversible thinking aspects	Problem-solving indicators
Negation Subjects use the properties of related inverse operations in creating new equations. *Reciprocity* The subject uses compensation properties or other equivalent relationships known to create new equations.	*Understanding the problem* The subject understands the problem by comprehending the information in the question. *Devising a plan* The subject can determine other conditions if there are unknowns, using all the information in the question and devising a plan or steps to solve the given problem. *Carrying out the plan* The subject can work on problem-solving questions according to the steps based on the chosen solution method.
The capability to return to the initial data after obtaining the result The subject converts the new equation that has been created back to its original form using the appropriate procedure	*Looking back* Subjects can recheck the results obtained using the appropriate methods or steps.

The Adversity Response Profile (ARP) questionnaire, adapted from Stoltz's theory, was used to determine students' Adversity Quotient (AQ) types. The RTT instrument consisted of essay tasks on contextual statistical problems designed to capture students' thinking processes. Semi-structured interviews were also conducted to confirm and further explore students' responses.

The study involved 21 eighth-grade students at MTs Annajah, Sungai Luar Village, Riau, Indonesia, who had previously studied statistics. Purposive sampling was used with the following criteria:

1. Students had completed the statistics unit in mathematics.
2. Students were willing to participate and provided informed consent.
3. Students represented different AQ types based on ARP results.

From the 21 students, five were selected for in-depth analysis and interviews: two climbers, two campers, and one quitter. The selection aimed to provide a balanced representation of the three AQ categories and to allow for detailed qualitative exploration.

Data were collected through ARP questionnaires, RTT tasks, and semi-structured interviews. The analysis followed Miles and Huberman's framework, which includes data reduction, data presentation, and conclusion drawing. In the reduction stage, data were simplified and categorized according to AQ type and students' RTT responses. The data were then presented in narrative, tabular, and visual forms before concluding. Students' responses were evaluated using the assessment rubric developed by Sugeng Sutiarso [30] (Table 2).

Table 2. Reversible thinking assessment rubric

Question No.	Aspect	Score	Description
1, 2, and 3	*Negation*	3	If it is correct to reverse the calculation operation related to the equation
		2	If performing the inverse operation on the calculation related to the equation is partially correct.
		1	If the inverse operation is performed on the calculation related to the equation, but the answer is incorrect.
		0	If the question is not answered
	Reciprocity	3	If you correctly use compensation or another relationship equivalent to the original equation
		2	If compensation or other relationships equivalent to the initial equation are used, but are only partially correct
		1	If using compensation or other relationships equivalent to the initial equation, but incorrect
		0	If the question is not answered
	Ability to return to the initial data after obtaining the result	3	If correctly returning the problem created to the initial equation
		2	If the problem is returned to the initial equation, but only partially correct
		1	If returning the created problem to the original equation, but incorrectly
		0	If the question is not answered
Maximum score for questions 1, 2, and 3		33	

To ensure the credibility of the findings, data triangulation was applied by comparing results from questionnaires, RTT responses, and interviews. Member checking was conducted by confirming interpretations with participants. Ethical considerations included obtaining informed consent from students and their parents, ensuring voluntary participation, and maintaining the confidentiality of participants' identities throughout the research process.

3. RESULTS AND DISCUSSION

The analysis of students' reversible thinking abilities based on their Adversity Quotient (AQ) revealed apparent differences across the three AQ types. Students with the quitter type were unable to demonstrate all aspects of reversible thinking. Camper-type students were able to fulfill two of the three aspects, namely negation and reciprocity, but were inconsistent in the aspect of returning to the initial condition (looking back). Meanwhile, climber-type students were able to fulfill all three aspects of reversible thinking, though minor technical errors were still observed. These findings confirm that students with higher AQ demonstrate stronger reversible thinking in mathematical problem solving.

The results of the *Adversity Response Profile* (ARP) questionnaire are shown in Figure 1.

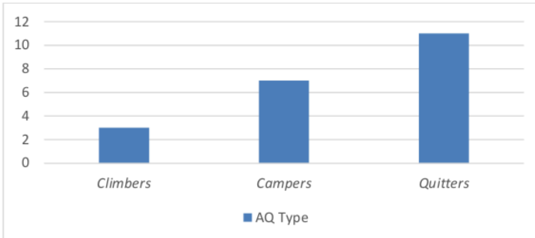

Figure 1. AQ Type Grouping Results

After completing the ARP questionnaire, students were given a test sheet titled "Thinking Reversible Test" (TTR). Students' answers were analyzed using reversible thinking indicators in solving mathematical problems in Grade VIII statistics material.

The results of the students' reversible thinking ability test in solving mathematical problems are presented in Table 3.

Table 3. Reversible thinking ability scores based on AQ type

AQ Type	Research Subject	*Reversible thinking* ability scores
Climbers	C1	28
	C2	21
Campers	M1	16
	M2	16
Quitter	Q1	5

The results of this study describe students' abilities to think reversibly when solving problems in eighth-grade statistics. Based on the results of the Thinking Reversible Test (TTR) and AQ type grouping, the researcher observed three aspects: negation, reciprocity, and the capability to return to the initial data after obtaining the result.

Table 4 summarizes the differences in reversible thinking abilities across the three AQ types.

Table 4. Comparative Differences in Reversible Thinking Abilities

Aspect of Reversible Thinking	Quitter	Camper	Climber
Negation	Not achieved	Achieved	Achieved
Reciprocity	Not achieved	Achieved	Achieved
Returning to the initial condition	Not achieved	Not achieved	Achieved

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The table highlights that climbers consistently fulfill all aspects of reversible thinking, campers partially fulfill them, and quitters do not demonstrate any of the aspects. These differences highlight the substantial impact of AQ on students' mathematical problem-solving abilities.

3.1. *Reversible thinking* ability in solving mathematical problems of the *quitter* type

The quitter student often abandoned the problem-solving process when facing difficulty. The student struggled to apply negation and reciprocity and did not attempt to verify the results. This indicates limited persistence and reflective ability, consistent with the quitter profile described by Stoltz.

Subject Q1 is unable to understand the problem, determine a plan/strategy, implement the plan, and verify the solution obtained. Subject Q1 is also unable to implement a systematic strategy to solve problems using a two-way approach, both forward and backward thinking. Q1 does not reverse equations and reverse operations that reflect *negation,* does not use other equivalent relationships in creating equations that show *reciprocity,* and is unable to return to the initial condition after finding a solution using the correct procedure. Subject Q1 demonstrated very low *reversible thinking* ability, made little effort to try various strategies, and did not retrace their answers. This reflects low AQ, namely a lack of resilience in facing challenges [31]. Based on interviews conducted with subject Q1, it was found that Q1 could not understand the problems in the questions and complained after reading them. This is in line with the research by Juwita Hesti et al. [32], which describes how *quitters* tend to give up easily and do not continue their thinking strategies when faced with difficulties, nor do they explore alternative solutions. This significantly impacts the development of higher-order thinking skills required in mathematics learning. Therefore, subject Q1 needs to be guided intensively through a scaffolding approach that encourages them to ask questions, recheck, and think about reciprocal relationships, allowing reversible thinking skills to develop.

3.2. *Reversible thinking* skills in solving mathematical problems of *the camper* type

The answers given by subjects M1 and M2 are those of students who tend to persevere in the face of problems, even though they are not yet fully capable of solving them correctly. Subjects M1 and M2 demonstrate a process *of reversible thinking* that is not yet stable and comprehensive. Both camper students were able to use negation and reciprocity appropriately in some contexts. For example, they applied inverse operations and equivalent relationships when constructing equations. However, they frequently stopped short of rechecking their answers, showing weaknesses in the "looking back" aspect. This suggests that while campers have the potential to solve problems, their lack of consistency prevents them from fully mastering reversible thinking.

Subject M1 shows that they are not yet able to develop *reversible thinking* skills stably and consistently. M1 can identify position reversal or inversion of operations (*negation*) and establish relationships between variables, but still has difficulty returning to the initial data after obtaining the results. Subject M1 demonstrates a basic understanding of mathematical operation reversal, but does not yet reflect metacognitively in a systematic manner. Based on an interview with subject M1, they can state known and asked information using their own understanding. They then made plans and carried them out, despite making mistakes in the calculation process. However, M1 was not yet able to verify the results against the initial conditions. Stoltz [22] revealed that *campers* showed low initiative and enthusiasm. As in this study, the subjects demonstrated fluent thinking but showed little initiative in working on problems and still sought the best answers.

3.3. *Reversible thinking* ability in solving *climbers-type* mathematical problems

The answers of subjects C1 and C2 are subjects that fulfill all aspects *of reversible thinking.* The climber students demonstrated the strongest reversible thinking skills. They consistently applied negation, reciprocity, and the ability to return to the initial condition. They also showed resilience by checking their results through multiple strategies. Although minor computational errors occurred, these students were able to correct mistakes and maintain logical reasoning. This supports Stoltz's view that climbers demonstrate persistence and adaptability in problem-solving.

Overall, subject C1 demonstrated fairly good *reversible thinking* skills. C1 demonstrated almost all aspects *of reversible thinking*, namely being able to reverse the process from the result to the data (*negation*), establishing relationships and linking information to create an equation model (*reciprocity*), and most importantly, retracing the results found to the initial conditions. However, C1 made a mistake in reversing the logic in question 1. This was confirmed in an interview, in which C1 admitted that his mistake in question 1 was due to incorrect algebraic transformations through equivalent operations. He also stated that he did not stop when he made the mistake, but instead tried again to construct the equation and obtain the correct mathematical model and solution. This process reflects that C1 possesses the characteristics of a climber in Stoltz's theory, exhibiting metacognitive abilities and the ability to maintain motivation. C1's mistake was not a failure, but a reflection of a developing thought structure. *Climbers* are individuals who do not give up when faced with obstacles but use mistakes as a stepping stone to learn and grow [31]. Subject C1 in questions 2c and 3c correctly performed the *looking back* stage but made mistakes in the calculations. This suggests that a process of checking the problem-solving answers was employed; however, arithmetic errors and a lack of understanding of the material hindered its effectiveness, in line with the results of Perbianti's [34]research, which describes obstacles in the reversible thinking process of students in algebra problems due to a limited understanding of mathematical concepts.

According to Jean Piaget, *reversible thinking* abilities begin to emerge in the concrete operational stage and continue to develop in the formal operational stage, typically experienced by children aged 7 to 11 years. Subject C2 demonstrated better *reversible thinking* abilities than subject C1. Although both subjects were classified as *climbers,* C2 was able to perform the backward thinking process better. He can reverse his thinking in re-verifying answers. C1 shows that *reversible thinking* is not only related to logic and calculation, but also sensitivity in reflecting on the thinking process and the courage to face complex challenges. In line with Juwita's [32] research, which describes how subjects with the *climber* type can relate information to prior knowledge and provide convincing arguments. Sugeng Sutisno [30] and Fadrik Adi [23] explain that metacognitive ability (awareness of the thinking process) is the key to deep mathematical thinking.

4. CONCLUSION

Students' reversible thinking abilities in mathematical problem solving are still far from optimal. The most common challenges include transformation errors and difficulty understanding the relationships between variables when constructing mathematical models. These weaknesses indicate limited mastery of fundamental mathematical concepts and strategies.

Based on the Adversity Quotient (AQ) classification, quitters showed weak reversible thinking abilities, unable to understand problems or plan appropriate solution strategies. Campers demonstrated partial mastery—successfully applying *negation* and *reciprocity* but failing to recheck their results or return to initial conditions. Climbers, on the other hand, fulfilled all three aspects—*negation*, *reciprocity*, and *returning to initial conditions*—demonstrating stronger persistence and reflective thinking. Overall, students with higher AQ scores exhibited greater flexibility, reflection, and accuracy in mathematical problem-solving.

These findings underscore the importance of teachers designing learning activities that foster reversible thinking through inquiry, reflection, and backward reasoning exercises. Mathematics curricula should integrate AQ-oriented learning approaches that foster resilience, persistence, and reflective thinking. For students, developing reversible thinking not only enhances problem-solving performance but also strengthens logical reasoning and mental adaptability when facing complex tasks.

This study was limited to a small sample of 21 eighth-grade students from a single school and focused on qualitative data. Therefore, the findings cannot be generalized to all student populations. The interpretation of results depends on contextual factors such as students' prior knowledge, motivation, and learning environment.

Future studies should involve larger and more diverse samples to validate these findings across educational levels. Experimental or quasi-experimental research could be conducted to measure the impact of specific interventions designed to enhance reversible thinking and AQ. Additionally, cross-level comparative studies—such as between elementary, junior high, and senior high school students—could provide a broader understanding of how reversible thinking develops across different stages of mathematical learning.

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