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How Adversity Quotient and Learning Independence Affect Students' Mathematical Problem-Solving Ability

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ABSTRACT

This study aims to analyze the influence of Adversity Quotient (AQ) and learning independence on students' mathematical problem-solving abilities and to explore problem-solving strategies based on differences in AQ and learning independence levels. The study employed a mixed-methods approach with a sequential explanatory design, involving 150 secondary school students. Results showed that AQ and learning independence significantly influenced problem-solving abilities, with learning independence having a greater impact. Students with high learning independence were more innovative and persistent, while those with low independence faced challenges. This study highlights the importance of developing AQ and learning independence to enhance students' problem-solving skills. Education should strengthen these aspects through strategies like project-based learning and resilience training, to better prepare students for real-world challenges.

1. Introduction

Adversity Quotient (AQ) is one of the key psychological factors in education, particularly in influencing students' mental resilience when facing challenges in the learning process (Hidayat et al., 2018; Safi'i et al., 2021). AQ, as proposed by Stoltz (1997), refers to an individual's capacity to face and overcome obstacles in life. In the context of education, AQ is closely related to students' ability to adapt to difficulties, such as complex mathematical problems that require critical

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thinking, focus, and perseverance (Putra et al., 2023; Qin et al., 2019).

Apart from AQ, another crucial factor in assessing students' ability to understand mathematics is learning independence. Learning independence refers to an individual's capacity to manage, plan, and take initiative in the learning process independently, without relying heavily on external support from teachers or peers (Zimmerman, 2002). Independent students tend to have high motivation, manage their time effectively, and seek the necessary resources to achieve their learning goals. Learning independence encompasses aspects of decision-making, planning, problem-solving, and self-evaluation within the educational context (Schunk, 2012; Zimmerman, 2002).

Problem-solving is one of the key elements in mathematics learning. It encompasses the ability to understand problems, formulate strategies, and identify as well as apply solutions (Kurnila et al., 2023). According to (Bariyyah, 2021; Franestian et al., 2020; Suparman et al., 2021), mathematical problem-solving ability involves an intelligent and rational cognitive process to identify problems and develop logical solutions. This process begins with problem recognition and concludes with achieving a solution, relying on sensory perception and critical thinking. Such ability is crucial for helping individuals effectively address everyday challenges.

To achieve excellence in mathematical problem-solving, individuals require a sufficient level of Adversity Quotient (AQ) and learning independence. AQ plays a vital role in building students' mental resilience when dealing with mathematical problems that require reasoning and strong analytical skills. This is supported by the findings of Lestari & Juandi (2023), who discovered that students with a high AQ demonstrate better problem-solving skills. Meanwhile, learning independence is essential, as self-reliant students can manage their learning processes more effectively, seek solutions independently, and overcome challenges with minimal external assistance. This aligns with the research conducted by Ismail et al. (2024), which states that students with high learning independence excel in communication and the utilization of mathematical tools, contributing to enhanced problem-solving abilities.

Social arithmetic in the mathematics curriculum is often a challenging topic for students. This area not only demands understanding of basic arithmetic concepts and linear programming but also their application in real-life contexts, such as financial problems, price comparisons, discounts, and interest rates. Research by (Hidayat et al., 2018; Naimnule et al., 2020; Pradika et al., 2019) indicates that students with higher mental endurance and positive attitudes toward difficulties tend to perform better in solving mathematical problems. Conversely, students with low AQ often feel overwhelmed or even avoid problems involving complex calculations in everyday contexts. Additionally, learning independence enables students to focus and stay consistent in solving problems while motivating them to keep learning and striving despite challenges. A combination of high AQ and good learning independence can significantly enhance students' efficiency and success in solving mathematical problems (Schunk, 2012; Zimmerman, 2002).

This study aims to analyze how Adversity Quotient (AQ) and learning independence influence students' ability to solve mathematical problems, particularly in the context of social arithmetic. The uniqueness of this research lies in combining two psychological variables—AQ and learning independence—

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within the domain of mathematical problem-solving, which are often studied separately. AQ, which focuses on an individual's ability to overcome obstacles and challenges, is expected to provide insights into how students manage cognitive and emotional difficulties when solving complex social arithmetic problems. Meanwhile, learning independence, encompassing self-management and initiative in the learning process, is seen as a crucial factor in enhancing problem-solving effectiveness, as independent students are better equipped to address challenges without relying on external assistance.

Another novelty of this study is the use of social arithmetic as a context for assessing mathematical problem-solving abilities, which is typically focused on other topics such as algebra or geometry. Social arithmetic involves the application of mathematical concepts to real-life scenarios, such as calculating discounts, profit, loss, taxes, or interest, requiring both analytical skills and practical understanding. Overall, this research contributes to the field of mathematics education by identifying psychological factors that enhance students' problem-solving skills and deepening our understanding of how AQ and learning independence interact in the context of social arithmetic.

Previous studies have shown that AQ is a key factor contributing to students' academic success across various domains, including mathematics (Safi'i et al., 2021). On the other hand, research by (Agoestanto & Masitoh, 2021) revealed that low AQ can pose significant barriers for students in developing the critical and analytical thinking skills needed to solve social arithmetic problems. Additionally, (Nuraini et al., 2023) demonstrated that learning independence also influences students' mathematical problem-solving abilities.

This study is expected to provide valuable insights for teachers and educators into the critical roles of AQ and learning independence in enhancing students' mathematical problem-solving abilities, particularly in social arithmetic. By leveraging these insights, teachers can design teaching strategies that focus on improving students' AQ and learning independence, helping them develop the skills needed to address various challenges in mathematics learning. Consequently, this research has the potential to make a practical impact on curriculum development and teaching approaches, promoting the reinforcement of AQ among students.

This study aims to enrich our understanding of the relationship between Adversity Quotient (AQ) and learning independence and their impact on students' mathematical problem-solving abilities, specifically in social arithmetic. The findings of this research can serve as a foundation for further studies exploring other psychological factors influencing problem-solving skills and evaluating the effectiveness of teaching strategies that emphasize the development of AQ and learning independence in mathematics education.

2. Method

The research approach employed in this study is a sequential explanatory design with a mixed-methods approach. The instruments used include questionnaires and tests. The questionnaire was designed to measure students' Adversity Quotient (AQ) and learning independence, while the test assessed their mathematical problem-solving abilities. The study began with the collection and analysis of quantitative data, followed by the collection and analysis of qualitative data to derive comprehensive conclusions from the findings

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(Wahyuni et al., 2024).
In the initial phase, quantitative data were gathered to evaluate the influence of AQ and learning independence on students' mathematical problem-solving abilities. In the second phase, semi-structured interviews were conducted to gain deeper insights into the quantitative results.

The study sample consisted of 150 students. This research examined how AQ and learning independence contribute to students' mathematical problem-solving abilities. Data on AQ and learning independence were collected using a Likert scale questionnaire ranging from 1 ("never") to 4 ("very often"). The data were analyzed using multiple regression tests to determine the significance of the relationships between variables. Subsequently, AQ and learning independence data were categorized into several groups: high AQ, low AQ, high learning independence, and low learning independence. To deepen the analysis, two students were selected as research subjects based on these categories: one student with high AQ and low learning independence, and another student with low AQ and high learning independence. This selection was made to provide a more specific understanding of their strategies in solving mathematical problem-solving tests, which were explored through in-depth interviews.

The influence of AQ and learning independence on arithmetic problem-solving abilities was analyzed using multiple regression tests, with problem-solving test scores as the dependent variable. Qualitative data analysis, including test results and interview protocols, followed an analysis model (Hembree, 1990) comprising data reduction, data presentation, and conclusion drawing. The validity of the quantitative data was tested through instrument validation procedures, including content validity assessed by expert judgment and reliability analysis using Cronbach's alpha. For the qualitative data, triangulation was applied by comparing the results of interviews, problem-solving test results, and observation notes to ensure the credibility and consistency of the findings. The test results were then compared between students with high AQ and low learning independence and those with low AQ and high learning independence.

3. Results and Discussion

A total of 150 vocational high school students completed questionnaires on AQ and learning independence, followed by solving mathematical problem-solving tasks. The test results are presented in the following table:

Table 1. Statistical Descriptions for Adversity Quotient, Learning Independence, and Problem-Solving Ability

	Mean	**Standard Deviation**
Adversity Quotient	60.31	12.20
Learning Independence	60.93	12.43
Mathematical Problem-Solving Ability	79.64	6.89

Table 1 above presents the statistical descriptions for the variables Adversity Quotient, Learning Independence, and Problem-Solving Ability. The mean value for the Adversity Quotient is 60.31 with a standard deviation of 12.2, indicating a moderate variation in students' ability to endure challenges. The mean for Learning Independence is 60.93 with a standard deviation of 12.43, showing a relatively similar variation. Meanwhile, Problem-Solving Ability has a mean

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score of 79.64 with a standard deviation of 6.89, reflecting a good level of problem-solving ability among students with smaller variability compared to the other two variables.

Before applying multiple linear regression to address the research questions, prerequisite analysis or classical assumption tests were conducted, including tests for normality, linearity, multicollinearity, and heteroscedasticity. In this study, the normality test was performed using a Normal P-P Plot on regression residuals. The results of this analysis are presented in the following figure:

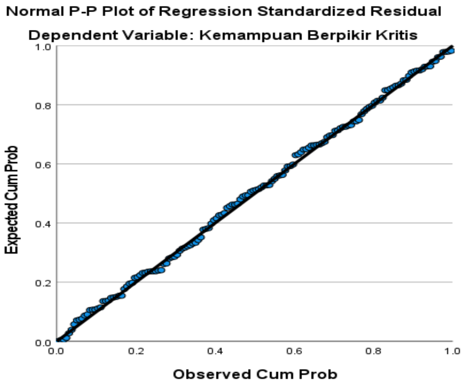

Figure 1. Normality Assumption Test P-Plot

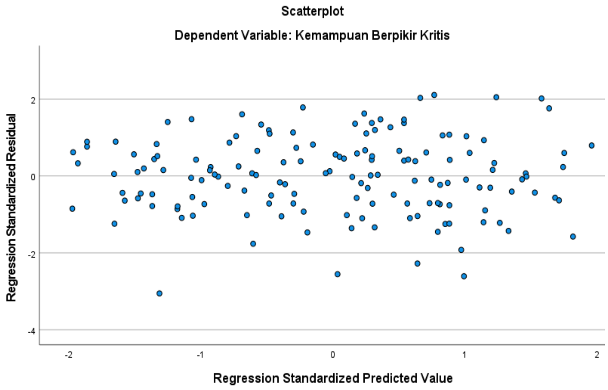

Figure 2. Heteroscedasticity Assumption Test Scatterplot

The plot above shows that the residual points are scattered around the diagonal line, indicating that the residual distribution is approximately normal. The deviation of the points from the diagonal line is minimal, leading to the conclusion that the data meets the normality assumption. This aligns with the statement by Purnomo (2017), who explained that the normality test in regression models is used to examine whether the residuals generated by the regression are normally distributed. One method for testing normality is by observing the distribution of data on the Normal P-P Plot; if the points are scattered around the line and follow the direction of the diagonal line, the residuals are considered normal (Lestari, et al., 2024). Therefore, the regression model used is deemed valid for further analysis. After confirming that normality is met, the next step is to conduct a heteroscedasticity test using a scatterplot.

Figure 2 presents the scatterplot for the heteroscedasticity test, utilizing residuals and standardized predicted values from the Problem-Solving Ability variable. The scatterplot shows that the residual points are randomly distributed around the horizontal line (axis 0) without displaying any particular pattern. The distribution does not form any widening (fan-shaped), narrowing, or curved patterns. Based on this pattern, it can be concluded that there is no indication of heteroscedasticity in the regression model. This conclusion is supported by Olvera Astivia & Zumbo (2019), who state that heteroscedasticity is usually defined as "non-constant error variance," indicating that the residual variability changes as a function of something not included in the model. They suggest that a scatter plot of residuals versus fitted values can be used to explore heteroscedasticity; a non-random pattern, such as a wedge-shaped (fan-shaped) pattern, can be indicative of heteroscedasticity. Similarly, Cho, et al. (2022) explains that in the context of linear mixed models, a scatter plot of residuals

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versus fitted values can reveal heteroscedasticity if patterns like a wedge shape are present. The absence of such patterns suggests homoscedasticity, meaning the variance of residuals is constant. Therefore, the random distribution of residuals around the horizontal axis without specific patterns in the scatterplot indicates that the assumption of homoscedasticity is met, and there is no evidence of heteroscedasticity in the regression model.

This study also involved a multicollinearity test to ensure that the independent variables, AQ and learning independence, do not have strong correlations with each other. Multicollinearity occurs when there is a significant relationship between independent variables. Since this study uses multiple linear regression analysis, it is important to avoid multicollinearity. Data is considered free from multicollinearity if the tolerance value exceeds 0.8 and the Variance Inflation Factor (VIF) is less than 10. The results of the multicollinearity test are presented as follows:

Table 2. Multiple Linear Regression Analysis

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
Model		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	54.459	3.155		17.260	.000		
	Adversity Quotient	.142	.038	.251	3.700	.000	.993	1.007
	Learning Independence	.273	.038	.492	7.237	.000	.993	1.007

a. Dependent Variable: Mathematical Problem-Solving Ability

Based on the Coefficients Table above, the analysis results indicate no multicollinearity between the independent variables, AQ and learning independence. This is evidenced by a tolerance value of 0.993, which exceeds the minimum threshold of 0.1, and a Variance Inflation Factor (VIF) value of 1.007, which is below the upper limit of 10. Therefore, the regression model is free from indications of multicollinearity and can be used for further analysis. This conclusion is supported by O'Brien (2007), who stated that a VIF value above 10 is often considered indicative of serious multicollinearity; however, this threshold should be evaluated in the context of other factors influencing the variance of regression coefficients. Hence, the VIF value of 1.007 in this analysis indicates that multicollinearity is not a significant issue in the regression model used.

To evaluate the influence of each independent variable on the dependent variable, a partial t-test was conducted using multiple regression analysis. This study examines how AQ and learning independence individually affect mathematical problem-solving ability, as detailed in Table 2. The resulting multiple linear regression equation is:

$$y = 54.459 + 0.142X_1 + 0.273X_2 \quad (1)$$

where X_1 represents AQ, X_2 represents learning independence, and y denotes mathematical problem-solving ability.

The regression analysis results indicate that both independent variables, AQ and learning independence, have a significant influence on the dependent variable. This is supported by the significance value (Sig.) of 0.000 (< 0.05) for

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AQ, indicating that its influence on problem-solving ability is statistically significant. The regression coefficient (B) of 0.142 shows that a 1% increase in AQ contributes to a 0.142% increase in problem-solving ability, assuming other variables remain constant. Similarly, the significance value (Sig.) of 0.000 (< 0.05) for learning independence demonstrates a significant impact on problem-solving ability, with a regression coefficient (B) of 0.273. This implies that a 1% increase in learning independence improves problem-solving ability by 0.273%, assuming other variables are held constant.

From Table 2, it can be observed that the t-values for AQ (3.7) and learning independence (7.237) exceed the critical t-value (1.655), indicating that AQ and learning independence are good predictors in the multiple linear regression model. Therefore, this model demonstrates that AQ and learning independence significantly contribute to enhancing students' problem-solving abilities.

After evaluating the partial effects of each variable, the simultaneous influence of AQ and learning independence on problem-solving ability was analyzed using the F-test. If the significance value (Sig.) is below 0.05, it can be concluded that AQ and learning independence jointly influence problem-solving ability, as shown in Table 3 below.

Table 3. ANOVA Test Results

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2307.957	2	1153.979	35.548	.000^b
	Residual	4771.939	147	32.462		
	Total	7079.896	149			

a. Dependent Variable: Mathematical Problem-Solving Ability
b. Predictors: (Constant), Learning Independence, Adversity Quotient

Based on Table 3, the results of the ANOVA test indicate that the overall regression model is significant in predicting problem-solving ability based on Adversity Quotient (AQ) and learning independence. The calculated F-value (35.548) is greater than the critical F-value (3.058), with a significance value (Sig.) of 0.000, which is less than 0.05. This demonstrates that AQ and learning independence simultaneously have a significant effect on students' mathematical problem-solving ability. This conclusion is supported by studies showing that AQ plays an essential role in mathematics learning, particularly in problem-solving, reasoning, and creativity. Students with high AQ exhibit superior abilities in understanding, planning, executing, and evaluating problem solutions and possess strong semiotic reasoning (Putra, et al., 2023). Moreover, the analysis of variance (ANOVA) is commonly used to test the overall significance of a regression model. The F-test in ANOVA evaluates whether the regression model provides a better fit to the data compared to a model without predictor variables. An F-value greater than the critical F-value indicates that the regression model is statistically significant (O'Brien, 2007). Thus, the significant ANOVA results suggest that the regression model, which includes AQ and learning independence, has a meaningful influence on students' mathematical problem-solving ability.

Therefore, AQ and learning independence can be considered important factors influencing students' problem-solving skills. The percentage contribution of AQ and learning independence to problem-solving ability is presented in the

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following table:

Tabel 4. Model Summary AQ, Kemandirian Belajar dan Kemampuan pemecahan masalah

Model Summary[b]				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.571[a]	.326	.317	5.69756

a. Predictors: (Constant), Learning Independence, Adversity Quotient
b. Dependent Variable: Mathematical Problem-Solving Ability

Referring to Table 5, it is evident that Adversity Quotient (AQ) and learning independence contribute **32.6%** to the problem-solving ability of vocational high school students, as indicated by the R-square value.

3.1. Description of Student Responses Based on AQ and Learning Independence Levels Subject with Low AQ and High Learning Independence (CEA)

In solving this problem, the first step taken by the CEA subject is to identify the variables needed to solve the problem. Next, the subject states and writes down all information about the problem comprehensively and sequentially, as shown in Figure 3 below:

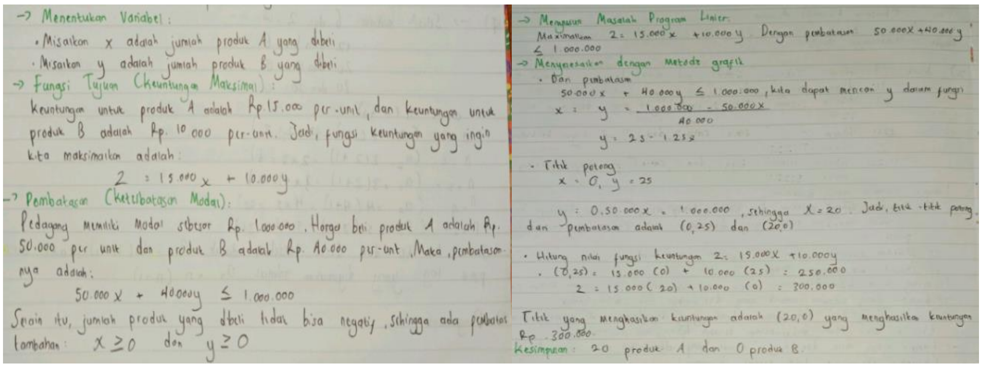

Figure 3. CEA Subject's Answer Sheet

Based on Figure 3, it can be observed that the CEA subject understands the step-by-step process to solve the problem. This includes defining variables, formulating the objective function, determining constraints for profit, identifying test points, and evaluating the objective function to arrive at the total products to be purchased to maximize the trader's profit.

To confirm the subject's AQ, learning independence, and problem-solving ability, the researcher conducted an interview with the subject. The results of the interview can be seen in the following transcript:

R : What do you usually do when faced with a very difficult problem that you cannot solve immediately?
S : Usually, ma'am, if the problem is difficult and I can't solve it, I often feel frustrated and confused.
R : How do you feel when you try to solve the problem but fail several times?
S : Hehe, usually if I fail several times, I feel hopeless, ma'am. It feels like

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all my efforts are in vain, and I lose the motivation to try solving it again.

R : Do you often study independently?
S : Yes, ma'am, I do.
R : What do you usually do to understand new material independently?
S : When there is new material, I prefer rereading the material in the book or looking for explanation videos online. I also try to solve practice problems on my own to understand the concepts better.
R : Do you have a study schedule outside school hours?
S : Yes, ma'am, I do. At home, after dinner, I usually set aside one or two hours for studying. During this time, I usually finish my assignments or just work on practice problems.
R : Okay, now let's look at solving this problem. How do you determine the first step when solving a problem involving several steps or concepts like this one?
S : Usually, ma'am, I read the problem carefully and write down the given information and what is being asked. Then, I think about the most logical step to take first. Like in this problem, I started by reading the question, writing down the information, and solving it step by step based on what I understood.
R : Do you usually recheck your work?
S : Yes, ma'am, I do. Especially when I understand the concept well, I make sure to do it properly and double-check to see if my work is correct.
R : If you find two different ways to solve a problem, how do you decide which one is better?
S : I usually choose the method I understand best—one that is simpler or faster to give the answer, as long as the result is still correct.

Based on the interview results above, it has been confirmed that this subject possesses a low Adversity Quotient (AQ), as indicated by their tendency to feel easily frustrated and discouraged when facing difficulties. However, they demonstrate a high level of independent learning through their initiative in self-study and maintaining a regular study schedule. Additionally, the student exhibits strong problem-solving skills, as evidenced by their systematic approach to understanding, solving, and analyzing mathematical problems.

3.2. Subject with High AQ and Low Independent Learning (YGAM)

In solving this problem, the initial step taken by this subject was to write down the information they understood related to the problem. Subsequently, they proceeded to solve the problem based on their understanding. The problem-solving process of the YGAM subject can be seen in the following figure:

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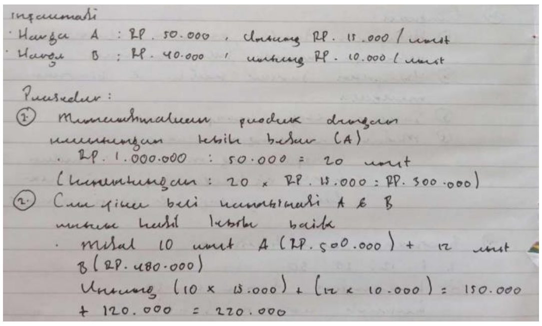

Figure 4. Answer Sheet of Subject YGAM

Based on Figure 4 above, the student's work shows that they have a basic understanding of the initial information in the problem but face difficulties in planning and devising a systematic solution strategy. YGAM correctly listed the purchase price of products A and B, as well as the profit per unit for each product. The subject's understanding of the basic information in this problem is quite good. Additionally, the subject tried to calculate the maximum number of units of product A that could be bought with the available capital. However, YGAM focused only on one product (product A) without considering the combination of products A and B to maximize profit. This indicates that YGAM did not understand that the goal of the problem was to find the optimal combination of products A and B. In the next step, YGAM tried to calculate the profit from purchasing product A and part of product B randomly (10 units of A and 12 units of B). This step shows that YGAM has not used a systematic approach (such as a system of linear equations or a combination table) to find the combination that maximizes profit. The main mistake made by YGAM was not considering all possible combinations of units of A and B within the budget constraint of Rp1,000,000. The subject also did not check if the total capital matched the number of units selected.

To confirm the AQ, learning independence, and problem-solving abilities of the student, the researcher conducted an unstructured interview with YGAM. The results of the interview can be seen in the following interview transcript:

R : What do you usually do when you encounter a very difficult problem or one that cannot be solved immediately?

S : Usually, ma'am, when I find a difficult problem and can't solve it, I often ask a friend sitting next to me or someone I'm close to for help in solving the problem together.

R : How do you feel when you try to solve the problem but fail several times?

S : Hehe, honestly ma'am, I usually think, 'Maybe there's something wrong with my steps.' So, I try again with a different approach. Or if not, I immediately ask a friend whom I think can help.

R : Do you often study independently?

S : Not often, ma'am. I usually prefer learning when someone explains, like a teacher in class or a friend. When I study alone, I often get confused about where to start, so I tend to wait for an explanation or help from someone else.

R : I see. Ok, now let's look at how you solved this problem. How do you

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determine the first step when solving a problem that involves multiple steps or concepts, like this one?

S : I usually read the problem carefully first, ma'am, then write down the information I know, like the prices of the products or the profits. After that, I try to calculate the maximum number of one product that can be bought with the available capital. If there are further steps, I try to solve them as I understand, for example, calculating the total profit from the number of products I've selected.

R : Okay, in this solution, you first calculated the profit for one product. Can you tell me why?

S : I think, ma'am, it's easier to focus on one product first because if I try to calculate both products at once, I'm afraid I'll get confused and make mistakes. So, I try to solve one at a time first.

R : Alright, then why did you end up using 10 units of product A and 12 units of product B in this solution?

S : Actually, ma'am, I don't quite understand the right way to solve this problem. I don't know the correct combination for the number of products A and B, so I just randomly tried the numbers 10 for product A and 12 for product B. At that time, I thought the result was close to the available capital, so I used that for the number of products A and B.

Based on the interview results, it has been confirmed that the respondent shows a fairly good AQ, as seen from their willingness to keep trying and not giving up easily, even after failing several times while solving the problem. They are able to learn from their failures and try different approaches to solve the problem. However, this respondent lacks independence in learning, which suggests that they need more external support or guidance in the learning process. Their learning independence could be improved through practice, such as starting to study without relying on others or more frequently overcoming difficulties on their own. The respondent's problem-solving ability is still lacking. Although they attempt to approach the problem in a structured way, they do not apply the correct concepts to find the solution, instead resorting to trial and error to arrive at a solution. This indicates a lack of confidence in determining the correct steps.

Based on the summary of the research data, it was found that the average Adversity Quotient (AQ) of students was 60.31 with a standard deviation of 12.20, indicating that most students have a moderate level of resilience when facing difficulties. According to (Erza et al., 2024), an AQ in the moderate category reflects that students tend to be able to persevere in difficult situations, although they are not yet optimal in overcoming challenges independently. In addition, the average learning independence score was 60.93 with a standard deviation of 12.43, showing a similar distribution to AQ. Zimmerman (1990) emphasizes that learning independence is an important predictor of academic success, where students with high independence tend to have greater intrinsic motivation. The mathematical problem-solving ability, with an average of 79.64 and a standard deviation of 6.89, indicates that students generally have good skills in solving complex problems. This finding is in line with research by (Agustin et al., 2024), which states that mathematical problem-solving ability is influenced by experience and repeated problem-solving practice.

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In this study, the multiple linear regression analysis showed that AQ and learning independence contribute positively to mathematical problem-solving ability. The regression coefficient for AQ was 0.142, confirming that an increase in AQ directly improves problem-solving ability. Research by (Pratiwi & Mudrikah, 2024) supports this finding, where high AQ is positively correlated with perseverance in solving complex problems. Meanwhile, the regression coefficient for learning independence was 0.273, indicating that this variable has a greater influence. This is in line with research by Karlen et al. (2021), which found that students with high learning independence are more likely to seek innovative solutions. Since learning independence has a more significant influence than AQ, it can be concluded that even if a student has low AQ (like subject CEA), this does not preclude them from demonstrating good problem-solving skills, as explained in the findings of this study. Conversely, students with low learning independence (like subject YGAM) tend to struggle in solving problem-solving tasks, especially due to a lack of independent practice and learning outside the school environment.

Based on the simultaneous test results (F Test), the calculated F value of 35.548, which is greater than the F table value, indicates that AQ and learning independence together have a significant effect on problem-solving ability. This finding is consistent with research by (Code, 2020; Dadandii, 2023), which shows that psychological factors and self-learning skills have a synergistic impact on academic achievement. The coefficient of determination (R Square) value of 0.326 indicates that 32.6% of the variability in problem-solving ability is explained by AQ and learning independence. The remaining variability is explained by other factors, such as learning experience and environmental support. Although the R Square value is not very high, it is sufficient to show that the model is relevant in the context of education.

The integration of quantitative and qualitative research results provides deeper insights into the relationship between AQ, learning independence, and mathematical problem-solving ability. Quantitatively, the regression analysis highlights that both AQ and learning independence significantly influence problem-solving ability, with learning independence showing a greater effect. This aligns with the qualitative findings, where students with high learning independence (e.g., subject CEA) demonstrated systematic and effective problem-solving strategies despite having low AQ. Conversely, students with high AQ but low learning independence (e.g., subject YGAM) struggled to independently develop structured solutions, highlighting their reliance on external guidance. These findings suggest a complementary relationship: while AQ supports persistence and resilience, learning independence plays a more prominent role in fostering autonomy and innovation in problem-solving. The combined results emphasize that enhancing both traits simultaneously can lead to more robust improvements in students' academic performance.

The implications and conclusions of these findings emphasize the importance of improving AQ and learning independence as key factors in developing mathematical problem-solving ability. An educational approach that integrates mental resilience training and the development of learning independence will yield more optimal results. Therefore, schools and educators are encouraged to design programs that encourage students to enhance AQ and learning independence through challenging activities and self-reflection.

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4. Conclusions

Based on the findings of this study, it can be concluded that Adversity Quotient (AQ) and learning independence significantly contribute to students' mathematical problem-solving abilities. Although the average AQ of students falls within the moderate category, indicating that they are capable of persevering in the face of difficulties, learning independence has a greater impact in enhancing their problem-solving skills. The regression analysis reveals that learning independence has a stronger influence than AQ on mathematical problem-solving ability, aligning with literature that links learning independence to better academic achievement. Furthermore, this study emphasizes that even students with low AQ can still demonstrate strong problem-solving skills, as long as they have high levels of learning independence.

The importance of psychological factors and self-learning skills as synergistic influences on academic performance is emphasized, consistent with the findings of the simultaneous test (F Test), which shows a significant effect of AQ and learning independence on problem-solving ability. Therefore, schools and educators need to design learning programs that integrate the development of AQ and learning independence, providing challenges that encourage students to practice and engage in self-reflection. This approach is expected to result in optimal improvements in mathematical problem-solving skills and overall academic achievement.

Author Contributions

This article was prepared by the first and second authors. Theoretical analysis and result interpretation were conducted by all three authors. Each author provided thorough feedback and contributed to the development of the study, analysis, and manuscript. The corresponding author, who is also the first author, revised the manuscript based on feedback from journal editors and reviewers.

Declaration of Competing Interest

No potential conflict of interest was reported by the author(s).

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