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Implementation of Problem-Based Learning with Module Assistance to Enhance Mathematical Literacy in Terms of AQ

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Abstract

The current issue in education in Indonesia is the low quality of education, particularly reflected in students' struggles with mathematics literacy. This study aims to analyze the quality of Problem-Based Learning (PBL) with module assistance and examine how students' mathematics literacy profiles are influenced by their Adversity Quotient (AQ) in PBL. This mixed-methods research was conducted with eighth-grade students at SMP Islam Unggulan Fastabiq, involving two classes: experimental and control. The qualitative subjects were selected from the experimental class based on AQ test results, representing three AQ types: climber, camper, and quitter, with two students from each type. Quantitative data analysis was performed using IBM SPSS Statistics, while qualitative data analysis followed steps of data reduction, presentation, and conclusion. The results indicate that the quality of PBL with module assistance is rated as good, as evidenced by: (1) valid teaching materials during planning, (2) effective implementation with positive student feedback, and (3) successful evaluation of students' mathematics literacy. Students with the AQ climber type achieved all six mathematics literacy indicators, while camper-type students met four indicators, and quitter-type students only reached two.

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INTRODUCTION

Mathematics is a fundamental discipline crucial for the growth of many other fields. Carl Friedrich Gauss famously referred to mathematics as the "queen of sciences" (Yadav & Kumar Yadav, 2017). Similarly, Das (2019) stated that mathematics is recognized as the queen of all subjects due to its scientific basis, indicating its foundational role in both education and daily life. In the modern era, the focus is no longer solely on arithmetic but extends to mathematical literacy, which involves reasoning and problem-solving abilities (Rahmah Hayati, 2019). This aligns with the increasing need for 21st-century skills, including literacy, to address complex challenges in education and beyond. Literacy is crucial for enabling students to understand, utilize, and apply knowledge gained in school (OECD, 2017).

Mathematical literacy, defined as the ability to formulate, apply, and interpret mathematics in various contexts, plays an essential role in developing students' competencies (Atsnan et al., 2018; Hillman, 2014). It enables individuals to appreciate the relevance of mathematics in everyday life and verify solutions to problems (Andes et al., 2017; Rahmah Hayati, 2019). Despite its importance, Indonesia's performance in mathematical literacy on international assessments like PISA (Programme for International Student Assessment) has remained low. The 2022 PISA results placed Indonesia 70th out of 81 countries, with a mathematics score of 366, below the global average of 500. This decline from a score of 379 in 2018 underscores the urgent need for educational reform (OECD, 2022).

Preliminary studies in a junior high school in Grobogan revealed that students struggle with understanding and analyzing story problems, formulating mathematical models, and solving high-order thinking skills (HOTS) problems. Interviews with teachers confirmed that these issues are compounded by a lack of confidence and perseverance among students when faced with challenging tasks. This suggests that low mathematical literacy may be linked to psychological factors, including Adversity Quotient (AQ), which measures resilience in overcoming difficulties (Nilasari & Anggreini, 2019; Retnowati & Aqiilah, 2017)

Paul G. Stoltz introduced AQ as a critical factor for success, emphasizing the need for resilience in education. Research shows that AQ significantly influences learning outcomes, as it fosters persistence and creativity in problem-solving (Fatmahanik, 2018; Rukmana et al., 2016). Within the context of mathematical literacy, AQ helps students overcome obstacles and approach problems with a constructive mindset (Mawardhiyah & Manoy, 2018). To maximize students' reasoning, argumentation, communication, and modeling abilities, they require strong resilience to face challenges (Dwi Rahmawati et al., 2015).

Effective classroom learning is critical for addressing these challenges. However, poorly managed instructional methods often lead to low student engagement and comprehension (Istiyani et al., 2018; Moma, 2017). Problem-Based Learning (PBL), supported by well-designed modules, offers a promising approach. PBL emphasizes active student participation in solving real-world problems, fostering critical and analytical thinking (Maskur et al., 2020; Maslihah et al., 2021). Modules, as structured instructional materials, encourage independent learning and enhance focus during lessons (Ariwanti Fathonah & Mariani, 2020). The integration of PBL and modules has been shown to improve mathematical literacy by contextualizing learning and engaging students in meaningful problem-solving activities (Widi Priyonggo et al., 2019).

This study aims to address the low mathematical literacy of Indonesian students by examining the impact of the PBL model supported by modules. The research will focus on eighth-grade students learning linear equation systems, exploring the relationship between their mathematical literacy and AQ. By evaluating the effectiveness of this approach, the study seeks to contribute to innovative educational practices that can enhance student outcomes and improve Indonesia's international standing in mathematical literacy.

METHOD

The study aims to provide a replicable framework for future research by clearly presenting

the materials, equipment, and methods employed. According to Stoltz (2000), the research begins with the selection of appropriate instructional models, focusing on Problem-Based Learning (PBL) enhanced with modular resources. The use of PBL aligns with findings by Junianto & Wijaya (2019), who highlight its effectiveness in fostering critical thinking and practical problem-solving skills. Materials include validated teaching modules specifically designed for class VIII students, as described by Sari Asih (2021), These modules were structured systematically, ensuring alignment with educational standards (Depdiknas, 2008).

The research methodology incorporates a mixed-method approach, which combines quantitative data analysis via IBM SPSS Statistics with qualitative techniques such as data reduction and thematic analysis (OECD, 2017). Key steps include pre-testing, implementation of the learning intervention, and post-testing, supported by detailed observation sheets and validated assessment tools (Ariwanti Fathonah & Mariani, 2020). The instruments, including Likert-scale questionnaires and mathematical literacy tests, were validated using criteria established by Wardono & Mariani (2018). Statistical reliability and validity were assessed to ensure robust data analysis, as recommended by Stoltz (2007).

By adopting this approach, the study not only confirms the effectiveness of PBL in enhancing mathematical literacy but also demonstrates its utility in addressing adversity quotients among students, which Stoltz (2000) identifies as crucial for long-term academic success. This alignment of theoretical underpinnings with practical applications allows other researchers to replicate the study in varied educational settings.

RESULTS AND DISCUSSIONS

This study implemented the Problem-Based Learning (PBL) model assisted by modules, focusing on students' mathematical literacy viewed from their Adversity Quotient (AQ). The research was conducted over four classroom sessions using the system of linear equations in two variables as the subject matter, followed by two interview sessions and the distribution of AQ questionnaires. Data collection included pretests and posttests, involving 30 students from class VIII A SMP Islam Unggulan Fastabiq (academic year 2024/2025). The sample, comprising class VIII A (experimental group) and class VIII B (control group), was selected through cluster random sampling to ensure representativeness and homogeneity. Pretests were conducted on November 23, 2024, and posttests on November 29, 2024, with AQ questionnaires completed on the same dates. Interviews with selected subjects were held on November 30, 2024, based on specific criteria, including test results and communication abilities.

The instruments used in this study were pre-test and post-test essay questions, which were initially trialed on students from class IX A who had already learned about systems of linear equations in two variables. The trial test consisted of three essay questions, and the results of this trial were analyzed to refine the pre-test and post-test. The research also included tests for validity and reliability of the mathematical literacy test instruments, which were made up of three essay questions. The results of the trial are presented in the following table.

Table 1. SPSS Reliability Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Pre_Test_1	53.1613	132.206	.804	.	.908
Pre_Test_2	52.8387	142.340	.809	.	.907
Pre_Test_3	53.0323	150.366	.748	.	.915
Post_Test_1	52.8387	142.340	.809	.	.907
Post_Test_2	53.0323	150.366	.748	.	.915
Post_Test_3	53.1613	132.206	.804	.	.908

Table 2. SPSS Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.924	.927	6

Based on the SPSS analysis of validity and reliability, the results show that all pre-test and post-test items meet the required criteria. The Corrected Item-Total Correlation values from Table 1 exceed the critical value of 0.3550 (N = 31, α = 5%), indicating that all items are valid. Additionally, the Cronbach's Alpha value of 0.924 (92.4%) in Table 2 demonstrates that the items are reliable, as a construct is considered reliable if the value is greater than 0.60. Therefore, all pre-test and post-test items are both valid and reliable for use in the study.

Normality tests were conducted on the pretest data of students' mathematical literacy from both the control and experimental classes using the Kolmogorov-Smirnov test at a 5% significance level (p-value = 0.05).

Table 3. Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PreTest_KK	.143	30	.122	.912	30	.017
PreTest_KE	.141	30	.133	.905	30	.011

a. Lilliefors Significance Correction

The significance of the initial mathematics literacy data for the experimental class is 0.133 > 0.05, indicating that the data is normally distributed. Similarly, the significance for the control class is 0.122 > 0.05, also indicating that the data is normally distributed.

The homogeneity test of the initial data on students' mathematical literacy was conducted in both the experimental and control classes using the Homogeneity of Variances test with a significance level of 5% (p-value = 0.05).

Table 4. Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
2,914	1	58	,093

The conclusion drawn from the homogeneity test table is that since the significance of the initial mathematical literacy data is 0.93 > 0.05, the null hypothesis ($H0$) is accepted, indicating that both groups have homogeneous variances.

The research findings were analyzed using an Independent T-Test.

Table 5. Independent T-Test SPSS Results

Group Statistics

	Kelas	N	Mean	Std. Deviation	Std. Error Mean
Nilai	PreTest_KK	30	68,890	6,8188	1,2449
	PreTest_KE	30	68,095	9,3078	1,6993

The results in Table 5 show that the control class has a mean of 68.89, while the experimental class has a mean of 68.09, with a difference of 0.8. The Independent Samples T-Test indicates a Sig. 2-tailed value of 0.707 > 0.05, meaning there is no significant difference between the two groups.

The final test data for mathematical literacy underwent prerequisite tests, including normality and homogeneity tests, before hypothesis testing.

The normality test for posttest mathematical literacy data from both control and experimental classes was conducted using the Shapiro-Wilk test with a significance level of 5% (p-value = 0.05).

Table 6. Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Nilai_PosTest_KE	.125	30	.200*	.927	30	.040
Nilai_PosTest_KK	.138	30	.149	.919	30	.025

a. Lilliefors Significance Correction

The posttest mathematical literacy data for the experimental class showed a significance value of 0.2 (> 0.05), indicating a normal distribution. Similarly, the control class posttest data had a significance value of 0.149 (> 0.05), confirming a normal distribution.

Homogeneity of variance testing was conducted to determine whether the sample came

from the same population, ensuring the results could be generalized. The test used Levene's test with a significance level of 0.05 on normally distributed final test data from the experimental and control classes.

Table 7. Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Nilai	Based on Mean	1.074	1	58	.304
	Based on Median	1.077	1	58	.304
	Based on Median and with adjusted df	1.077	1	57.335	.304
	Based on trimmed mean	1.065	1	58	.306

The Levene's test for homogeneity in Table 4.12 shows Sig=0.304>0.05, indicating that the control and experimental groups have homogeneous variance.

The first hypothesis examines whether the average post-test score of mathematical literacy in the experimental class meets the mastery criterion of 70 ($\mu \geq 70$) using a one-tailed left test.

The research results were analyzed using hypothesis testing with a significance level of $\alpha = 5\%$ and a decision criterion to accept $H0$ if $t_{hitung} < t_{tabel}$.

$$t = \frac{\tilde{x} - \mu_0}{\frac{s}{\sqrt{n}}} = = \frac{\widehat{86{,}03} - 70}{\frac{9{,}5}{\sqrt{30}}} = 9{,}4$$

The one-tailed t-test showed a t-value of 9.4, which exceeds the critical t-value of 1.69 at a 5% significance level with 29 degrees of freedom. Therefore, H0 is rejected and H1 is accepted, concluding that the average posttest score of the experimental class in mathematical literacy reached the completion criteria after receiving Problem-Based Learning with module assistance.

The second hypothesis test was conducted to determine whether the posttest results of the experimental class's mathematical literacy ability met the classical proportion completeness of 75% ($\pi = 0.75$).

Table 8. Proportion Test Results

	Test Value = 75					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Nilai_PostTest_KE	7.651	29	.000	10.8737	7.9671	13.7802

The SPSS One Sample T-Test output shows a significance value of 0.000 < 0.05, indicating the rejection of H0 and that the proportion of students using PBL-assisted learning with modules exceeds the 75% completion threshold.

The third hypothesis test was conducted to determine whether the posttest average of mathematical literacy skills in the experimental class using Problem-Based Learning (PBL) assisted by modules was better than the posttest average in the control class using conventional learning methods. The test was performed using an independent sample t-test with posttest data from both classes. The SPSS output of the Independent Sample T-Test showed a significance value (2-tailed) of 0.000 < 0.05, indicating that the null hypothesis (H0) is rejected. This suggests that the average mathematical literacy skills of students in the PBL module-assisted class were better than or equal to those in the conventional learning class.

The proportion test was used to determine the difference in the number of students achieving mathematical literacy proficiency between the experimental and control groups.

The hypothesis test was conducted using a two-proportion test. The analysis involved 30 students in the experimental class, where 29 students passed, and 30 students in the control class, with 22 passing.

$$z = \frac{\pi_1 - \pi_2}{\sqrt{\hat{p}\hat{q}\left\{\left(\frac{1}{n_1}\right) + \left(\frac{1}{n_2}\right)\right\}}},$$

$$\hat{p} = \frac{x_1 + x_2}{n_1 + n_2}, \qquad q = \widehat{1 - \hat{p}}$$

$$\hat{p} = \frac{29 + 22}{30 + 30} = \frac{51}{60} = 0{,}85$$

$$\hat{q} = 1 - 0{,}85 = 0{,}15$$

$$z = \frac{\frac{29}{30} - \frac{22}{30}}{\sqrt{(0{,}85)(0{,}15)\left\{\left(\frac{1}{30}\right) + \left(\frac{1}{30}\right)\right\}}} = \frac{0{,}23}{\sqrt{(0{,}13)\{0{,}7\}}}$$

$$= \frac{0{,}23}{\sqrt{0{,}01}} = 2{,}3$$

Therefore, since z > z(0.5-α), or 2.3 > 1.64, the null hypothesis is rejected, indicating that the mathematics literacy completion rate of students in the PBL model with modules is higher than that of students in the conventional model.

The purpose of simple linear regression testing is to determine whether there is an influence of AQ (independent variable or X) on students' reading literacy.

A regression analysis between students' AQ and mathematical literacy using simple regression test with a 5% significance level in SPSS.

Table 9. Results Linear Regression Test

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.830[a]	.688	.677	4.42311

a. Predictors: (Constant), AQ
b. Dependent Variable: Literasi_Mtk

Table 9 shows that the R Square value is 0.688, or 68.8%, indicating that 68.8% of students' mathematical literacy ability can be explained by the AQ variable, while the remaining 32.2% is influenced by other variables not studied.

Table 10. Results Linear Regression Test

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1209.276	1	1209.276	61.812	.000[b]
	Residual	547.790	28	19.564		
	Total	1757.066	29			

a. Dependent Variable: Literasi_Mtk
b. Predictors: (Constant), AQ

Table 10 shows that the probability value (sig = 0.000) is less than 0.05, indicating that H1 is accepted, and the linear regression model can be used to predict students' mathematical literacy skills based on their AQ.

Table 11. Results Linear Regression Test

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	Constant	30.671	7.068		4.340	.000
	AQ	.710	.090	.830	7.862	.000

a. Dependent Variable: Literasi_Mtk

Table 4.17 shows the regression equation y = 30.671 + 0.710x with a significance value of 0.000 < 0.05. This indicates a significant influence of students' AQ on their mathematical literacy skills.

The sixth hypothesis test aims to determine whether students' mathematical literacy skills improve using Problem-Based Learning with the help of modules.

Table 12. Paired Samples Statistics Test

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreTest_KE	68.0957	30	9.30781	1.69937
	PostTest_KE	85.8737	30	7.78386	1.42113

Table 13. Paired Samples Correlations Test

		N	Correlation	Sig.
Pair 1	PreTest_KE & PostTest_KE	30	.982	.000

The paired sample t-test showed a mean pre-test of 68.09 and a post-test mean of 85.87. The paired samples correlation coefficient was 0.982 with a significance value of 0.000, indicating a strong relationship between the pre-test and post-test scores. The paired samples test revealed a significance value of 0.000 < 0.05, leading to the rejection of the null hypothesis and confirming an improvement in students' mathematical literacy through the PBL model with module assistance.

Next, the N-Gain test is conducted to determine the improvement in students' mathematical literacy skills after being taught using the Problem Based Learning model with the help of a module.

Table 14. Descriptives N-Gain of Mathematical Literacy Ability

			Statistic	Std. Error
N_Gain_Score	Mean		.5876	.02278
	95% Confidence	Lower Bound	.5410	

	Interval for Mean Upper Bound	.6342	
	5% Trimmed Mean	.5872	
	Median	.5646	
	Variance	.016	
	Std. Deviation	.12478	
	Minimum	.39	
	Maximum	.78	
	Range	.39	
	Interquartile Range	.23	
	Skewness	.370	.427
	Kurtosis	-1.170	.833

Based on the results of the N-Gain test calculation above, it shows that the average value of the N-Gain score for the mathematical literacy skills of the experimental class is 0.58, which means that the amount of improvement is included in the moderate category.

The implementation of hypothesis VI test was also carried out to test the increase in AQ, namely based on the questionnaire before and after treatment. Hypothesis testing uses a significance level of α = 5% with the test criteria, namely accept $H0$ if $sig\ (2\ taield) > 0.05$.

Table 15. Paired Samples Statistics Test AQ

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	AQ_ Sebelum	67.833	30	7.08609	1.29374
	AQ_ Sesudah	77.766	30	9.09692	1.66086

		N	Correlation	Sig.
Pair 1	AQ_Sebelum & AQ_Sesudah	30	,911	,000

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	AQ_Sebelum - AQ_Sesudah	-9.93333	3.94080	.71949	-11.40485	-8.46182	-13.806	29	.000

The paired sample t-test results show a mean AQ of 67.83 before and 77.76 after the learning process. The paired samples correlations table shows a correlation coefficient of 0.911 and a significance of 0.000, indicating a strong relationship between AQ scores before and after learning. The paired samples test shows a significance value of 0.000 < 0.05, meaning the null hypothesis is rejected, indicating an increase in Adversity Quotient in the experimental class.

Furthermore, to determine the average increase, the N-Gain test was conducted. The N-gain test was conducted to determine the magnitude of the increase in AQ before and after learning with the Problem Based Learning model assisted by modules.

Table 16. Descriptives N-Gain AQ

			Statistic	Std. Error
N_Gain_ScoreAQ	Mean		.3363	.032
	95% Confidence Interval for Mean	Lower Bound	.2708	
		Upper Bound	.4017	
	5% Trimmed Mean		.3308	
	Median		.2899	
	Variance		.031	
	Std. Deviation		.17526	
	Minimum		.08	
	Maximum		.68	
	Range		.60	
	Interquartile Range		.28	
	Skewness		.635	.427
	Kurtosis		-.783	.833

Based on the results of the N-Gain test calculation above, it shows that the average value of the AQ N-Gain score for the experimental class is

0.33, which means that the amount of improvement is included in the moderate category.

CONCLUSION

Based on the findings and discussions in this study, it can be concluded that the Problem-Based Learning (PBL) model assisted by modules is effective in improving the students' mathematical literacy. This is evident from the high quality of the learning process, as reflected in the validation of learning devices, the very good implementation of the learning process, and the excellent student responses. The average post-test scores of the students indicate that the learning model meets the established competency criteria, and the majority of students achieve the required literacy levels. Additionally, there was a significant impact of Adversity Quotient (AQ) on the students' mathematical literacy, with a moderate increase in both AQ and mathematical literacy after the intervention. Students with higher AQ (Climber type) demonstrated better mathematical literacy than those with lower AQ (Camper type), showing a positive correlation between AQ and learning outcomes. Furthermore, the use of modules in the PBL model helped students, particularly those with Camper-type AQ, to stay focused and structured in problem-solving tasks, fostering critical thinking and collaboration. The study also highlighted the importance of considering individual characteristics, such as AQ, in designing effective learning strategies. Overall, the research contributes to the understanding of how AQ influences the learning process and demonstrates the potential of the PBL model assisted by modules to improve not only mathematical literacy but also students' resilience in facing challenges. This study offers valuable insights for educators in adapting teaching methods to suit students' diverse needs, particularly in fostering resilience through problem-based learning.

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