

Mathematical resilience and learning climate in view of learning style: The impact of improving mathematical reasoning in vocational schools

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Abstract: This research aims to analyze the influence of mathematical resilience and learning climate on the mathematical reasoning of Vocational High School (SMK) students, as well as examine the role of learning style as a moderating variable. Mathematical resilience, which reflects students' ability to persist in facing difficulties in learning mathematics, as well as a positive learning climate, is thought to have an important contribution to mathematical reasoning abilities. The research used a quantitative approach. This research was conducted at two vocational schools in Malang with 200 respondents. Data was collected through mathematical resilience questionnaires, learning climate, learning styles, and mathematical reasoning tests, then analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4 software. Validity and reliability tests showed that all instruments used met the criteria determined, with an AVE value above 0.5 and a Composite Reliability value above 0.7, indicating a valid and reliable instrument. All indicators used in this research also met the significance test with a p-value below 0.05. The research results show that mathematical resilience has a significant influence on students' mathematical reasoning (path coefficient 0.237, t-statistic 3.803, p-value 0.000). The learning climate was also proven to have a positive effect on mathematical reasoning (path coefficient 0.287, t-statistic 4.125, p-value 0.000). However, learning style does not significantly moderate the influence of mathematical resilience on mathematical reasoning. Still, it plays a moderate role in the relationship between learning climate and mathematical reasoning (t-statistic 2.102, p-value 0.036). These findings provide insight into the importance of learning strategies that support resilience and learning climate to improve students' mathematical reasoning abilities at the vocational secondary education level.

Keywords: Mathematical Resilience; Learning Climate; Mathematical Reasoning; Learning Style

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INTRODUCTION

Mathematical reasoning is a key competency in Vocational High Schools (SMK) that influences academic success in mathematics and the development of critical thinking skills. Mathematical resilience is defined as students' ability to persist and adapt in facing and solving difficulties in learning mathematics. At the same time, it plays an important role in improving students' mathematical reasoning abilities. A study conducted by Anjani & Ulfah, (2022) showed that mathematical resilience has a significant effect on students' mathematical problem-

solving skills. Students who have high resilience tend not to give up easily when facing difficult mathematical problems. Instead, they use these challenges as opportunities to learn and develop (Turner, 2021; Xenofontos & Mouroutsou, 2023). Previous studies have shown that mathematical resilience positively relates to mathematical reasoning abilities as it encourages students to think more deeply and creatively in solving problems (Shengyao et al., 2024).

Moreover, the learning climate plays an important factor in influencing students' mathematical reasoning. Anastasios (2020) shows that a positive learning climate - constructive feedback and good interactions between students and teachers - increases students' motivation and engagement in mathematics learning, which could improve their mathematical reasoning abilities. However, the learning climate, including the quality of interactions between teachers and students and between students and their peers, plays a crucial role in supporting mathematical reasoning. A positive learning climate, where students feel supported and valued, increases their intrinsic motivation to learn and impacts their mathematical reasoning ability (Arum et al., 2023; Tomaszewski et al., 2024). In contrast, a negative learning climate can decrease students' interest and motivation, and have a negative impact on their reasoning abilities.

Also, learning style is another factor in moderating the influence of mathematical resilience and learning climate on mathematical reasoning. Each student has a different learning style, such as visual, auditory, or kinesthetic. The particular study examines whether a learning style can strengthen or weaken the influence of resilience and learning climate on students' mathematical reasoning abilities (Lohri-Posey, 2021; Saprianti et al., 2023). Therefore, students' learning styles can mediate how mathematical resilience and learning climate affect mathematical reasoning. Dana Wahyudi & Walid (2020) found that adapting teaching methods to students' learning styles maximizes their mathematical reasoning potential. Zulfah et al. (2021) also stated that students' mathematical reasoning abilities vary according to their learning styles.

The study examines the relationship between mathematical resilience, learning climate, and learning style in students' mathematical reasoning. It is important to determine learning strategies to improve students' mathematical reasoning abilities in secondary schools (Hutauruk & Priatna, 2017). Thus, this study provides in-depth insight into the factors that influence students' mathematical reasoning, individually and collectively. Also, it is expected to contribute to the development of more effective and adaptive learning strategies according to the needs and characteristics of students at the secondary education level.

Based on the background, the objectives of this study are to: (1) find out the effect of mathematical resilience on the students' mathematical reasoning of secondary education; (2) find out the effect of learning climate on the students' mathematical reasoning of secondary education; (3) determine whether learning style moderates the effect of mathematical resilience on students' mathematical reasoning; (4) find out whether learning styles moderate the influence of learning climate on students' mathematical reasoning; (5) find out the influence of mathematical resilience and learning climate simultaneously on students' mathematical reasoning at the secondary education level; and (6) find out the significant relationship between mathematical resilience, learning climate, and learning styles simultaneously on students' mathematical reasoning at the secondary education level.

METHODS

A quantitative approach with an explanatory design was employed to examine the influence of mathematical resilience, learning climate, learning styles, and students' mathematical

reasoning. This design allows for the analysis of the influence of these variables individually and simultaneously (Creswell & Creswell, 2018). This study involved grade X students at a vocational high school in Dampit Town, East Java Province because they have sufficient experience in mathematics. The sample consisted of approximately 200 students, from two vocational high schools, SMK Al Munir Dampit and SMK Bina Bangsa Dampit, which were selected using purposive sampling based on the diversity of learning styles and learning climate (Rivki et al., n.d., 2012). (Rivki et al., n.d. (2012). The selected vocational high schools were SMK Al Munir Dampit with 75 students and SMK Bina Bangsa Dampit with 125 students. The collection of exogenous data (mathematical resilience and learning climate), intertwining (learning styles), and endogenous (mathematical reasoning) was carried out at SMK An-Nur AL Munir Dampit Malang for 14 days, starting from July 26, 2023, to August 3, 2024, and at SMK Bina Bangsa Dampit Malang for 14 days, starting from August 3 to August 13, 2024.

The data collection technique used questionnaires and tests that were specifically designed to measure the research variables. The questionnaire measures mathematical resilience, learning climate, and learning styles, while the test measures students' mathematical reasoning. Data were collected directly at school and offline to reach more respondents (Arum et al., 2023). Meanwhile, the instruments used 1) Mathematical Resilience Scale, adapted from the Connor-Davidson Resilience Scale (CD-RISC), which has been validated in an educational context to measure students' resilience in facing academic challenges (Connor & Davidson, 2003). 2) Learning Climate Scale, adapted from the Learning Climate Questionnaire (LCQ), which measures students' perceptions of the support that they receive from their teachers and learning environment (Richard, 2020). 3) Learning Style Questionnaire, developed based on the Felder-Silverman model to identify students' learning styles, such as visual, auditory, and kinesthetic (Lohri-Posey, 2021). 4) The Mathematical Reasoning Test, compiled based on Learning Outcomes in the independent mathematics competency standards for grade X, aims to measure students' ability to think logically and systematically in solving mathematical problems (Kilpatrick, 2010).

The data analysis technique used Path Analysis with Partial Least Squares Structural Equation Modeling (PLS-SEM) modeling and will be analyzed using SmartPLS software version 4. Path analysis was employed because it tests the direct and indirect effects between the variables studied and identifies whether learning styles moderate the relationship between mathematical resilience and learning climate on mathematical reasoning. According to (Hair et al, 2019) , PLS-SEM is a multivariate statistic to test a series of influences between variables that are estimated simultaneously with the aim of predicting, exploring, or developing a structural model. The SmartPLS 4 is used as it has a limited sample size while the model being built is complex. Yamin (2021) stated that the PLS-SEM model includes the following two stages in testing the evaluation.

Stage 1: Testing the Feasibility of Research Instruments with Reflective Measurement Model Evaluation (Outer Model), namely conducting (a) Validity Test used to test research instruments by testing Convergent Validity with Loading Factor (> 0.708), AVE > 0.7 , Communality > 0.5 . Also, it tests Discriminant Validity, with Cross Loading (> 0.7), AVE root $>$ latent variable correlation, and HTMT (< 0.9) (Hair et al, 2023). (b) Reliability Test used to test the consistency of research instruments or the consistency of respondents' answers, using the Cronbach's Alpha test (> 0.9) and Composite Reliability (> 0.9) (Hair et al, 2023).

Stage 2: Research Hypothesis Test, the output of the research hypothesis test is an analysis of the direct and indirect influence of exogenous variables on endogenous variables. In other aspects, answers to the formulation of research problems are also found in a descriptive

analysis. The contents of the research hypothesis testing section include (1) Structural Model Evaluation, this model, in SEM PLS 4, is allocated to analyze the results of the chi-square determination coefficient, R^2 , Q^2 , SRMR, NFI, d_G , and, d_{ULs} (Hair et al, 2023). (2) Bootstrapping. The procedural steps of bootstrapping are the process of assessing significance to measure (a) direct influence, (b) indirect influence, (c) and overall influence (Hair et al, 2023)(Hair, J. F., Hult, T., Chritian, R., Sarstedt, M., Danks, P. N., & Ray, 2023). The significance level is obtained through the R^2 value, adjusted R^2 , F^2 , outer loading, and cross-loading. The bootstrapping procedure produces statistics to determine the influence of exogenous variables on endogenous variables. The p-value that plays as an indicator of significance, is obtained from the bootstrapping procedure. The original research sample is used as a regression coefficient in completing the structural equation (Henseler, J., & Sarstedt, M, 2013). (3) Blindfolding. This method is defined as a data analysis procedure in SmartPLS4 that provides predictive relationships in latent variables (Henseler, J., & Sarstedt, M, 2013). Research that has predictive relationships is the result of scientific research that can be assumed in the long term. The analysis process uses calculations, if $Q^2 > 0.05$, then the model is relevant in determining the results of the research scientifically, or the independent variable has been tested procedurally to be able to cause events in the actualized dependent variable. Meanwhile, the proposed hypothesis in this study is presented in Figure 1.

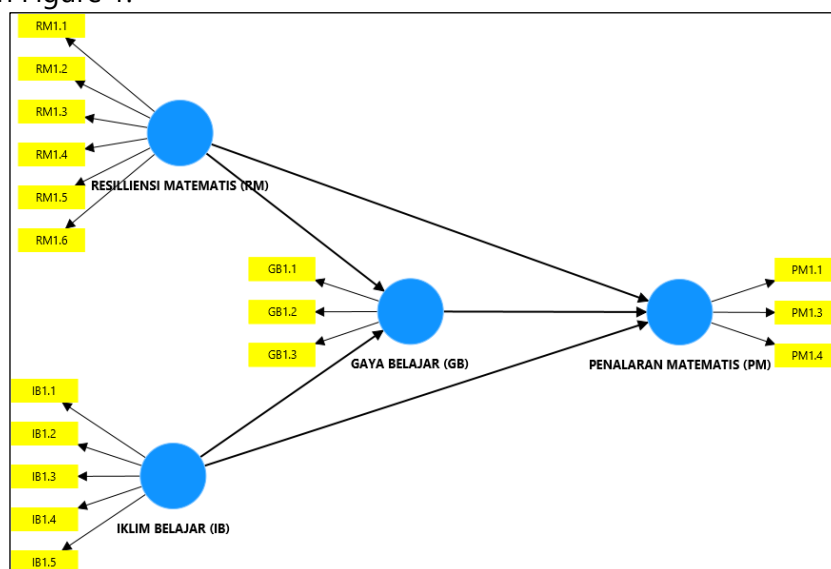


Figure 1. Model Analisis Jalur (Path Analysis)

The proposed hypotheses:

Direct Influence

Hypothesis 1 (H1): there is an influence of mathematical resilience on the mathematical reasoning of students in vocational high schools.

Hypothesis 2 (H2): there is an influence of mathematical resilience on the learning styles of students in vocational high schools.

Hypothesis 3 (H3): there is an influence of learning climate on the mathematical reasoning of students in vocational high schools.

Hypothesis 4 (H4): there is an influence of learning climate on the learning styles of students in vocational high schools.

Hypothesis 5 (H5): there is an influence of learning style on the mathematical reasoning of students in vocational high schools.

Indirect Influence

Hypothesis 6 (H6): to find out whether learning style can moderate the influence of mathematical resilience on mathematical reasoning of students in vocational high schools.

Hypothesis 7 (H7): to find out whether learning styles can moderate the influence of learning climate on mathematical reasoning of students in vocational high schools.

RESULTS AND DISCUSSION

Respondent Description

The primary data collection is the independent variable (exogenous), including mathematical resilience, learning climate, and intertwining variables: learning styles by distributing questionnaires. Meanwhile, test questions are used to measure endogenous variable data of mathematical reasoning of students at Vocational High Schools. The data collection of exogenous, intertwining, and endogenous was carried out on 125 respondents at SMK Bina Bangsa Dampit Malang from August 3 to August 13, 2024, and 75 respondents at SMK An Nur AL Munir Dampit Malang from July 26, 2023, to August 3, 2024. Then, there were 200 respondents in the study.

The respondents/students at SMK Bina Bangsa Dampit Malang and SMK An Nur AL Munir Dampit Malang are illustrated in Table 1.

Table 1. Respondent at SMK Dampit Malang

SMK Dampit Malang	Total	Percentage (%)
SMK Bina Bangsa	125	62,5
SMK An Nur AL Munir	75	37,5
Total	200	100

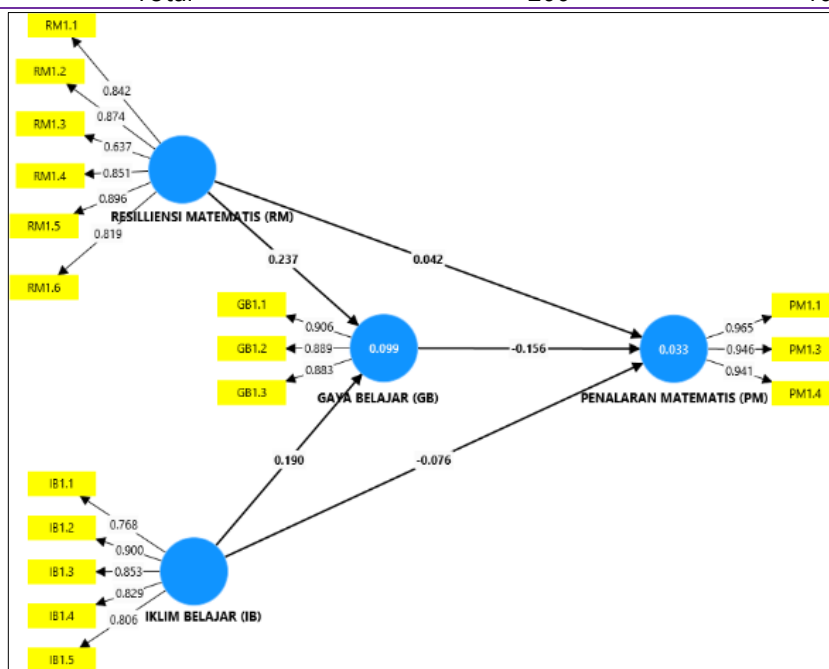


Figure 2 Main Model Diagram of PLS Algorithm Output Results of Outer Model

Furthermore, the questionnaire data and test question data were analyzed using the Partial Least Squares Structural Equation Modeling (PLS-SEM) method through SmartPLS 4 software, and a measurement model evaluation test (outer model) was carried out to test the valid and

reliability of the instruments. Research hypothesis testing included 1) Structural model evaluation, 2) Bootstrapping, and 3) Blindfolding. The results of the test are explained in the following description. Evaluation of Measurement Model (Outer Model).

This evaluation aims to ensure that the instrument met the standards and passed the validity and reliability tests, through Convergent Validity, Discriminant Validity, Indicator Reliability, and Internal Consistency Reliability tests (Ghasemy et al., 2021). Validity and reliability tests can be seen through the main model diagram of the PLS Algorithm output from the SmartPLS 4 software in a measurement model diagram (outer model), seen in Figure 2. And, complete outer loadings data from the measurement items is presented in Table 2.

The initial step is the Convergent Validity test, which aims to determine the validity of each relationship between indicators and their constructs or latent variables. In this study, it is seen from the main model diagram of the PLS Algorithm Output results in an Outer Model, as seen in Figure 2. Figure 2 shows all measurement items for each variable have met the validity test because, in the diagram, all Loading Factor (LF) values > 0.70 and 1 measurement item has an LF value > 0.60. And, according to (Dutta & Mandal, 2018) and (G. David Garson, 2018), all measurement items have met the Convergent Validity test. The validation results, considering the outer Loadings value and the reliability test of the research instrument, which were through the Cronbach's Alpha, Composite Reliability, and Average Variance Extracted tests, are presented in Table 2.

Table 2. Outer Loadings, Cronbach's Alpha, Composite Reliability, and Average Variance Extracted

Variable	Measurement Items	Outer Loadings > 0.70	Where	Cronbach's Alpha > 0.70	Composite Reliability > 0.70	AVE > 0.50	Where
Mathematical Resilience (RM)	RM1.1	0.842	Valid	0.907	0.979	0.679	Reliable
	RM1.2	0.874	Valid				
	RM1.3	0.637	Valid				
	RM1.4	0.851	Valid				
	RM1.5	0.896	Valid				
	RM1.6	0.819	Valid				
Learning Climate (IB)	IB1.1	0.768	Valid	0.89	0.929	0.693	Reliable
	IB1.2	0.900	Valid				
	IB1.3	0.853	Valid				
	IB1.4	0.829	Valid				
	IB1.5	0.806	Valid				
Learning Style (GB)	GB1.1	0.906	Valid	0.873	0.879	0.797	Reliable
	GB1.2	0.889	Valid				
	GB1.3	0.883	Valid				
Mathematical Reasoning (PM)	PM1.1	0.965	Valid	0.947	0.957	0.904	Reliable
	PM1.3	0.946	Valid				
	PM1.4	0.941	Valid				

Note: Recommendations from (Ghasemy et al., 2021), the one-tailed 95% percentile confidence intervals (5%, 95%) of the reliability and validity statistics have been provided. CR = Composite Reliability; AVE = Average Variance Extracted.

Table 2 shows that the Loading Factor (LF) or outer loadings value is > 0.70 for all measurement items and 1 measurement item of RM1.3 obtained LF: 0.637 > 0.60, according to (G. David Garson, 2018) met the Convergent Validity test. Also, the AVE value is > 0.50 for each variable. Thus, based on the LF value > 0.70 and the AVE value > 0.50, it concluded that the measurement items of all variables have met the good Convergent Validity test.

Furthermore, the reliability test of the instrument (measurement) of each variable is carried out, namely Indicator Reliability and Internal Consistency Reliability. In Table 2, the Internal Consistency Reliability test can be seen through the high Composite Reliability (CR) value indicating the consistency value of each indicator in measuring its construct. The Composite Reliability (CR) value > 0.70 . Meanwhile, to test the Indicator Reliability, Cronbach's Alpha is used. This value reflects the reliability of all indicators in the model. The value of Cronbach's Alpha > 0.70 , (Ghasemy et al., 2021). Based on the results of the analysis, it shows that all Composite Reliability (CR) and Cronbach's Alpha values > 0.70 , it can be concluded that the Indicator Reliability and Internal Consistency Reliability of the measurement variables have met the reliability level criteria test or all constructs have good reliability. Based on the evaluation of the measurement model against the Main Model Figure 2, it is concluded that the measurement model has met the good validity and reliability tests so that it can be further evaluated. Furthermore, a structural model evaluation test is carried out for hypothesis testing.

Structural Model Evaluation (Inner Model)

Structural model evaluation is an evaluation of hypothesis testing. The influence between variables is presented in the path coefficient or coefficient. According to (Edeh et al., 2023; Ghasemy et al., 2021), structural model evaluation test includes (1) SmartPLS4 Multicollinearity Assumption Test, collinearity testing is a mandatory requirement before bootstrapping in the process of analyzing structural equation models. (2) Model Eligibility Evaluation. And (3) Structural Model Analysis, is a hypothesis test in PLS-SEM, carried out through the bootstrapping method with a t-table statistic value of 1.96 or a p-value of 0.05, which indicates a significant influence between variables. Testing of confidence interval 95% path coefficient, the size or value of the confidence interval for the influence value (path coefficient) between variables 95%, is used to determine the minimum and maximum values of the influence between the resulting variables. (3) F Square Test, explains the category of direct influence of variables at the structural level. According to (Hair et al, 2023), the interpretation of the F Square value is low influence (F Square = 0.02), medium (F Square = 0.15), and high (F Square = 0.35). Meanwhile, the category of indirect influence, according to Lachowicz et.al., (2018), is obtained by squaring the mediation coefficient (Upsilon V), namely low mediation influence (0.01), medium mediation influence (0.075), and high mediation influence (0.175).

SmartPLS4 Multicollinearity Assumption Test

The assumption test in multicollinearity is a requirement before bootstrapping under the process of analyzing structural equation models. Data Interpretation from SmartPLS 4 can be reviewed in (1) the inner model VIF value and (2) the List Accumulative VIF Model. Many researchers have chosen to use the list accumulative VIF model because all the data interpretation can be directly analyzed when it meets the IF requirements. The requirement for the VIF is a VIP coefficient value of ≤ 5.00 , so if the VIF value does not meet these requirements, then it occurred multicollinearity symptoms that lead to the data not being able to be bootstrapped.

The first stage is to test the collinearity of the latent variables. The results of the collinearity test (see Table 3) show that the Inner VIF values of all combinations of exogenous latent variables, intertwining variables, and endogenous variables are all lower than 5. Then, there is no collinearity in the structural model. So, the bootstrapping procedure can be employed to test the research hypothesis.

Table 3. Collinearity Statistics (VIP)-Inner Model

Variable Construction for Exogenous and Endogenous	VIF < 5
Learning Style (GB) -> Mathematical Reasoning (PM)	1.110
Learning Climate (IB) -> Learning Style (GB)	1.006
Learning Climate (IB) -> Mathematical Reasoning (PM)	1.046
Mathematical Resilience (RM) -> Learning Style (GB)	1.006
Mathematical Resilience (RM) -> Mathematical Reasoning (PM)	1.069

Evaluation of Model Quality and Suitability

Feasibility Analysis of Inner Model through R Square

The test is central because if one of the variables, targeted by the independent construct is in extra low fit or ≤ 0.10 , then the analysis might not be performed through bootstrapping that used to review the direct and indirect effects according to the hypothesis design. The output of testing the model is carried out through the R Square value, which is part of the PLS-SEM inner model. R Square is a method used to review the value of the dependent construct, which can be explained by the independent construct. R square testing describes the value of the variation in endogenous variables that can be explained by exogenous variables or other endogenous variables in the model. The coefficient of determination (R Square) shows, according to (G. David Garson, 2018) the interpretation value of R square is 0.19 (low influence), 0.33 (moderate influence), and 0.66 (high influence).

Table 4: R Square Determination Coefficient

	R-square	R-square adjusted	Interpretation
Learning Style (GB)	0.199	0.190	Low (about 0.19)
Mathematical Reasoning (PM)	0.133	0.118	Low (about 0.19)

Table 4 shows that the model obtained from the research data is moderate or r square adjusted of 0.190 and 0.118, which means weak or low. The determination coefficient of R square, in Table 6, can be concluded if mathematical resilience (RM) and learning climate (IB) together have an influence on learning style (GB) of 0.199 with an R Square adjusted value of 0.190. All exogenous constructs (RM and IB) affect GB by 19%. Therefore, the conclusion of the influence of RM and IB on GB is low. The R Square value of RM and IB and GB on PM is 0.133 and the adjusted R Square is 0.118. This means that the exogenous constructs together (RM, IB, and GB) have a low influence of 11.8% on mathematical reasoning ability. These results showed that the exogenous constructs together have a low impact on the endogenous construct. The accumulative value of the R Square Adjusted is 30.8% of 100%, obtained from the constructs together on mathematical reasoning ability. In short, 69.2% of mathematical reasoning ability is determined by other variables that have not been studied.

Feasibility Analysis of Standardized Root Mean Residual and Non Fit Index SmartPLS4

In addition to determining its feasibility through R Square, the structural equation model in SmartPLS 4 is also analyzed using standardized root mean residual and non-fit index. The main basis of the model criteria is (1) SRMR value ≤ 0.10 , (2) d_{uls} value of ≥ 0.05 , (3) d_G value of ≥ 0.05 , (4) chi-square of ≤ 3.00 or expected to be small and (5) NFI of ≥ 0.80 is a good fit.

Based on Table 5, all models are in the good fit criteria, except in the form of chi-square is in ≥ 3.00 , which has not met the good fit criteria. However, the research model is fit or feasible because the range of values is not far from 3.00. Based on these results, the results of the research and development of the model are robust. A new from SmartPLS 4 is the degree of

data trust that can be measured from (1) d_ULs and (2) d_G, then, based on the new interpretation with the estimated model results ≥ 0.05 , the data has good fit criteria in terms of trustworthiness.

Table 5. Standarized Root Mean Residual and Non-Fit

	Saturated Model	Estimated Model	Criteria Estimated Model	Interpretation
SRMR	0.058	0.058	≤ 0.10	Good Fit
d_ULS	0.522	0.522	≥ 0.05	Good Fit
d_G	0.263	0.263	≥ 0.05	Good Fit
Chi-square	31.369	31.369	≤ 3.00	Fit
NFI	0.869	0.869	≥ 0.80	Good Fit

Feasibility Analysis through Predictive Relevance Q Square

Predictive relevance (Q^2) is a test stage through blindfolding, which aims to provide a presentation of results if the dependent variable has a predictive relationship with the intended independent variable. The conclusion of the q square is quite simple, if the value of $\sum Q^2 \geq 0$ then the construct has predictive relevance status to its independent variable.

Table 6. value of Q^2 Predictive Relevance

Indicators	Q^2 predict	PLS-SEM_RMSE	PLS-SEM_MAE
GB1.1	0.050	4.268	3.384
GB1.2	0.051	5.252	4.169
GB1.3	0.060	5.963	4.878
PM1.1	0.014	5.379	4.479
PM1.3	0.009	5.253	4.443
PM1.4	0.017	5.434	4.587

Based on Table 6, the results of Q^2 for the RM and IB variables on GB have predictive relevance because ≥ 0.000 . The exogenous variables as a whole (RM, IB, and GB) have Q^2 of ≥ 0.000 for each mathematical reasoning variable. Various final data processing from blindfolding show that the data is suitable to be continued in bootstrapping analysis to determine the research hypothesis.

Structural Model Analysis (Hypothesis Testing)

This model analysis is a hypothesis testing in PLS-SEM, carried out through the bootstrapping method. Furthermore, hypothesis test is carried out by testing the significance and relevance of the path coefficient. And, the significance value of the path coefficient of each path that connects the latent variables will be analyzed through the Bootstrapping procedure. The results are presented in Table 7.

Table 7. Hypothesis Testing of Direct Effect (Path Coefficient and P-Values)

Path Model	Path Coefficient	T Statistics	P-Values	95% Confidence Interval Path Coefficient		F Square	Where
				Min Limit	Max Limit		
H1: GB -> PM	-0.156	2.230	0.013	-0.275	-0.045	0.023	Accepted/ Negative
H2: IB -> GB	0.190	2.492	0.006	0.072	0.317	0.040	Accepted
H3: IB -> PM	-0.076	0.977	0.164	-0.200	0.058	0.006	Rejected
H4: RM -> GB	0.237	3.803	0.000	0.154	0.347	0.062	Accepted
H5: RM -> PM	0.042	0.512	0.304	-0.093	0.177	0.002	Rejected

A hypothesis testing table is obtained as the results of data analysis through the Bootstrapping procedure, by looking at the direct influence, namely the results of the Path Coefficient and P-Values with a significance level of 5%, presented in Table 7. Interpretation of the results in Table 9 are as follow.

The first hypothesis (H1) is accepted. There is a significant influence but negative of Learning Style (LS) on Mathematical Reasoning (PM) with a path coefficient value of (-0.156), t statistic (2.230 > 1.96), and p-value (0.013 < 0.05). This means that increasing learning styles tends to decrease the mathematical reasoning of students at vocational high schools. Meanwhile, decreasing learning style tends to increase the mathematical reasoning of students at vocational high schools, although the influence is relatively low (f square = 0.023).

The second hypothesis (H2) is accepted. There is a significant positive influence of Learning Climate (LCL) on Learning Style (LS) with a path coefficient value of (0.190), t statistic (2.492 > 1.96), and p-value (0.006 < 0.05). This means that every increase in learning climate will increase the learning style of students at vocational high schools. In the 95% confidence interval, the influence of learning climate in increasing learning style is between 0.072 to 0.317 with a low influence category with an f square value of 0.040.

The third hypothesis (H3) is rejected. There is no influence of Learning Climate (IB) on Mathematical Reasoning (PM) with a path coefficient value of (-0.076), t statistic (0.977 < 1.96), and p-value (0.319 > 0.05). This means that the learning climate does not have a direct effect on the mathematical reasoning of students at vocational high school.

The fourth hypothesis (H4) is accepted. There is a significant positive influence of Mathematical Resilience (RM) on Learning Style (GB) with a path coefficient value of (0.237), t statistic (3.803 > 1.96), and p-value (0.000 < 0.05). This means that changes in mathematical resilience improve learning styles. Students with high resilience are better able to adjust and adapt to various learning styles to overcome mathematical difficulties. In the 95% confidence interval, the effect of mathematical resilience on improving learning styles is between 0.154 and 0.347, with a low influence category and an f-square value of 0.062.

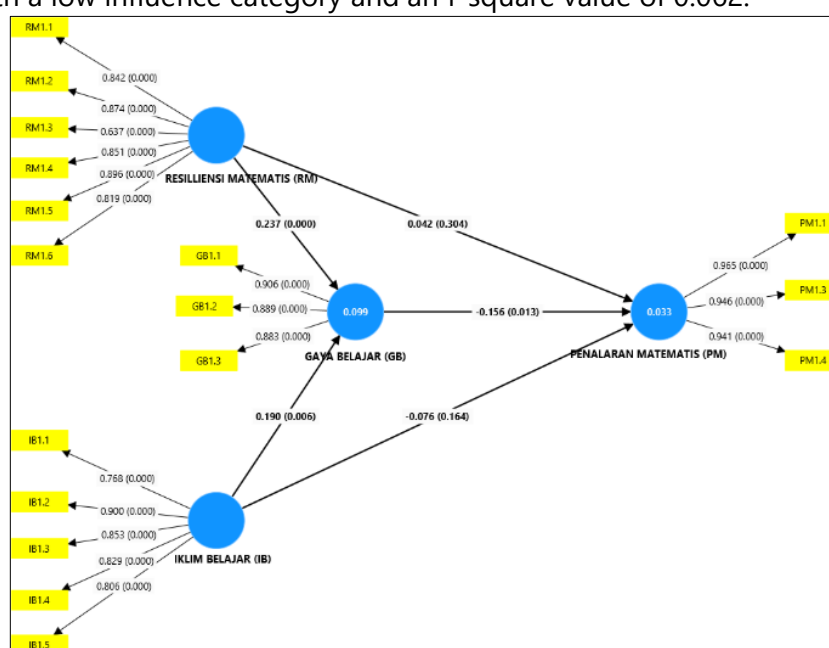


Figure 3. Model of Path Coefficient and P-Values

The fifth hypothesis (H5) is rejected. There is no effect of Mathematical Resilience (RM) on Mathematical Reasoning (PM) with a path coefficient value of (0.042), t statistic (0.512 < 1.96),

and p-value (0.304 > 0.05). This means that mathematical resilience does not have a direct effect on the mathematical reasoning of students at vocational high schools. These findings are also clarified in the Path Coefficient and P-Values models in Figure 3. Meanwhile, the hypothesis test of indirect influence between exogenous and endogenous variables is presented in Table 8.

Table 8. Hypothesis Test of Indirect Influence (Path Coefficient and P-Values)

Path Model	Path Coefficient	T Statistics	P-Values	95% Confidence Interval of Path Coefficient		Upsilon Vor F Square	Where
				Min Limit	Max Limit		
H6: IB-> GB-> PM	-0.030	1.569	0.058	-0.075	0.000	0.0009	Rejected/ Low Mediation
H7: RM-> GB-> PM	-0.037	1.745	0.041	-0.083	-0.003	0.0014	Accepted/ Low Mediation

Table 8 shows the hypothesis test of the indirect influence of the Path Coefficient, P Values, and the Upsilon V test (obtained from the Upsilon formula of $V = \beta^2_{MX} \beta^2_{YM.X}$ with the criteria (0.175) high mediation influence, (0.075) moderate mediation influence, and (0.01) low mediation influence). The results are.

The sixth hypothesis (H6) is rejected, where the learning style variable does not significantly play as a mediating variable. It means that learning style cannot moderate the influence of learning climate on students' mathematical reasoning in vocational schools. Because the mediation path coefficient value is (-0.030), t statistic (1.569 < 1.96), and p-value (0.058 > 0.05). At the structural level, the role of learning mediation is included in the low mediation influence category (with an Upsilon V value = 0.0009) (Ghasemy et al., 2021).

The seventh hypothesis (H7) is accepted, where the learning style variable is significantly playing as a mediating variable. It means that learning style moderates the influence of mathematical resilience on the mathematical reasoning of students in vocational schools. The mediation path coefficient value is (-0.037), t statistic (1.745 < 1.96), and p-value (0.041 < 0.05). Therefore, the structural level of the mediation role of learning style is in the low category (with an Upsilon V value = 0.0009) (Ghasemy et al., 2021).

Discussion

The results of the first hypothesis (H1) show a significant negative influence between learning style and mathematical reasoning of students in vocational high school in Islamic boarding schools, with a path coefficient of -0.156, a t-statistic of 2.230, and a p-value of 0.013. It means that every increase in learning style is related to a decrease in mathematical reasoning. Vice versa, a decrease in learning style can increase students' mathematical reasoning. It reflects the complex relationship between learning style and mathematical reasoning in the context of Islamic boarding schools that limit the use of technology.

In Islamic boarding schools, where technology is not available, kinesthetic or auditory learning styles may be less effective than text-based and discussion-based learning styles. For example, students who rely on visual learning may have difficulty understanding mathematical concepts without visual aids such as videos or digital graphics, which can reduce their mathematical reasoning skills that require abstract thinking and symbolic manipulation (Sutinah & Ristiana, 2023) ; 51].

In addition, teaching methods in Islamic boarding schools that do not use technology may focus more on classical approaches such as lectures and face-to-face discussions. If students' learning styles do not match these methods, they may experience a decrease in their mathematical reasoning. Research shows that learning styles that are not well accommodated by teaching methods, can limit the development of complex cognitive skills (Jose DELA TORRE Bearneza & Jose Bearneza, 2023; Ridwan et al., 2019).

Overall, these results suggest that in Islamic boarding schools with technological restrictions, adjusting teaching methods to students' learning styles is important to reduce negative impacts on mathematical reasoning. A flexible and inclusive approach can help students overcome their limitations in learning style and improve mathematical reasoning skills (Setiawan et al., 2020; Vale & Barbosa, 2023).

The results of the second hypothesis (H2) show a significant positive effect of learning climate on the learning styles of students in vocational schools, with a path coefficient value of 0.190, a t-statistic of 2.492, and a p-value of 0.006. This indicates that improving the learning climate contributes to improving students' learning styles. In the context of vocational schools in Islamic boarding schools that prohibit the use of cellphones and technology, these results provide important insights into the dynamics of learning in a more traditional environment.

The learning climate in Islamic boarding schools, which includes student engagement, affiliation, support from educators, task orientation, and competition, can significantly affect students' learning styles even when technology is not available. Student engagement in learning activities can be increased through more conventional teaching methods, such as group discussions or project-based activities, which are relevant in the context of Islamic boarding schools. Research shows that active engagement, even in a technology-free environment, still influences students' learning styles, especially in more structured and directed contexts (Ayodele & Olalekan, 2017).

The interaction of students in Islamic boarding schools can enhance their learning styles through strong social support and collaboration among peers. In an Islamic boarding school environment where social interactions occur more frequently in a more informal and collaborative format, students can motivate each other and share learning strategies without the need for technological tools. Research shows a positive social affiliation can encourage students to develop more effective learning styles, even without technological support (Antelm-Lanzat et al., 2020; Fathani & Artikel, 2019)

Educators' role in Islamic boarding schools, although not supported by modern technology, still plays a crucial role in facilitating students' learning styles. They often focus more on pedagogical approaches that emphasize values and ethics, as well as more traditional teaching methods. This support, in the form of direct guidance and personal feedback, still plays an important role in helping students identify and develop their learning styles (MAHAMA et al., 2021).

The third hypothesis (H3) states that the learning climate does not have a direct influence on the mathematical reasoning of students in vocational high schools in Islamic boarding schools. It shows that factors such as student involvement, student affiliation, educator support, task orientation, and competition in learning, do not significantly affect students' ability to do mathematical reasoning. The factor is, although a positive learning climate is important to create a conducive environment, specific aspects of mathematical reasoning may be more influenced by other factors such as individual cognitive abilities, intrinsic motivation, and more personal learning experiences (Fathani & Artikel, 2019; Gunawan et al., 2019).

In the context of vocational schools in Islamic boarding schools prohibiting the use of cellphones and technology, the third hypothesis (H3) shows no direct influence of learning climate on mathematical reasoning, which can be explained by limited access to technological resources. In an Islamic boarding school environment, student involvement, student affiliation, support from educators, task orientation, and competition may not fully support the development of mathematical reasoning because traditional learning methods rely more on lectures and memorization than on the exploratory and analytical approaches, needed to build mathematical reasoning skills (Gunawan et al., 2019; Siahaan & Meilani, 2019).

The prohibiting practice of technology use limits students' access to visual and interactive tools that usually help them develop abstract skills, such as mathematical reasoning. Mathematical reasoning requires the ability to manipulate concepts, make conjectures, and draw conclusions based on patterns or properties of mathematical phenomena. In a technology-free environment, students rely more on materials orally or in writing, which may not be enough to train their critical and analytical thinking skills (Antelm-Lanzat et al., 2020; Holil et al., 2023). Support from educators in the Islamic Boarding School environment is often more about moral and spiritual development than cognitive development. It may become a reason why the learning climate does not have a direct impact on mathematical reasoning. Furthermore, although student engagement and affiliation are important for creating a harmonious learning environment, these aspects may have a higher impact on attitudes and behavior than specific academic skills such as mathematical reasoning (Kasih et al., 2021; La Kalamu & Djafar, 2022).

Task-oriented and competitive learning may also not be sufficient to facilitate the development of mathematical reasoning in the context of Islamic boarding schools as it requires intellectual challenges involving in-depth exploration. Meanwhile, in a technologically limited environment, students tend to focus on understanding and applying concepts traditionally. Competition may encourage students to achieve good results in exams, but it is not enough to encourage the development of higher reasoning skills (Dan et al., 2024; MAHAMA et al., 2021).

In conclusion, the learning climate in a vocational high school environment in an Islamic boarding school without technological support may not be enough directly to influence mathematical reasoning. Learning that focuses on memorization and limited access to interactive learning resources creates a positive learning climate but is unable to fully develop students' mathematical reasoning abilities. This emphasizes the importance of developing more innovative and adaptive learning methods that are appropriate to the conditions of Islamic boarding schools (Fathani & Artikel, 2019; Jazuli Yusup et al., 2021).

The fourth hypothesis (H4) shows a significant positive influence of mathematical resilience on the learning styles of students in vocational high school. It highlights the importance of the affective aspect in training students' learning approaches. Mathematical resilience, which includes perseverance, self-confidence, the ability to work hard, and adaptability to challenges and failures, contributes directly to students' ability to develop effective learning styles, including visual, auditory, and kinesthetic (Azizah & Abadi, 2022). This finding is consistent with the literature showing that students with high levels of resilience tend to be more flexible in choosing and adapting learning styles for their needs.

Mathematical resilience plays an important role in the learning styles of students in vocational high schools in Islamic boarding schools that prohibit cell phones and technology because they have to rely on non-digital strategies. This condition requires students to develop

perseverance, creativity, and adaptability in using limited resources (MAHAMA et al., 2021; Shengyao et al., 2024).

Furthermore, the prohibition practice on the use of technology challenges students to develop auditory and kinesthetic learning styles. With no access to videos or interactive applications, students in Islamic boarding schools must rely more on verbal discussions and learning through direct experiences, such as practice and experimentation in learning mathematics. But, it supports the importance of resilience in helping students navigate these challenges and achieve deep understanding through learning methods that are appropriate to their context (Al Asyari, 2022; Rohmah & Roihanah, 2022).

Finally, although mathematical resilience plays an important role, technological restrictions also challenge educators in Islamic boarding schools to be more creative in designing supportive learning environments. Traditional learning aids and collaborative learning approaches are key in helping students develop appropriate learning styles. Thus, mathematical resilience not only improves students' learning styles but also encourages innovation in learning approaches in a limited environment by the rules and regulations of Islamic boarding schools (La Kalamu & Djafar, 2022; Mulyawati & US, 2023).

The rejection of the fifth hypothesis (H5) that mathematical resilience does not have a significant effect on the mathematical reasoning of students in vocational high schools in Islamic boarding schools that are not allowed to use mobile phones and technology. Also, it highlights the specific challenges in this environment. In Islamic boarding schools, which often have a traditional educational approach and are limited in the use of technology, student's ability to access various learning resources and external support is very limited. As a result, even though students may have high perseverance and confidence, limited access to digital learning aids can be a challenge to the development of their mathematical reasoning (La Kalamu & Djafar, 2022; Mulyawati & US, 2023).

In Islamic boarding schools, learning that uses direct interaction and verbal instructions can reduce students' opportunities to develop creativity and innovative solutions in mathematics because they cannot use technology such as simulations, videos, or interactive software. It affects resilience indicators such as generating new ideas and finding creative solutions to be ineffective in supporting the development of mathematical reasoning, such as drawing conclusions or identifying mathematical patterns (Edeh et al., 2023; Shengyao et al., 2024).

Restrictions in the use of technology also affect how students in Islamic boarding schools adapt to the challenges of learning mathematics. Without access to additional learning resources, students must rely on direct support from teachers and peers. However, in this context, the ability to communicate and discuss with peers may not be enough to significantly improve mathematical reasoning skills, especially in terms of mathematical manipulation or verifying mathematical arguments, which require deep understanding that is usually reinforced by visual aids or technology (Rohmah & Roihanah, 2022).

Furthermore, although mathematical resilience is important in maintaining student motivation, the *pesantren* (Islamic Boarding Schools) environment—which tends to be more structured and disciplined—can reduce flexibility in learning. Without technological support, students' learning experiences are more limited to conventional methods that may not sufficiently challenge their critical and analytical thinking skills. This contributes to the results showing that mathematical resilience has no direct effect on mathematical reasoning (Azizah & Abadi, 2022).

Therefore, the rejection of hypothesis H5 confirms that, in the context of the *pesantren* practice of technology restriction, there is an urgent need to integrate more innovative and

interactive learning approaches that do not rely on and use technology. Problem-based or project-based learning strategies that directly involve students in mathematical exploration and problem-solving can be an effective alternative to developing mathematical reasoning while maintaining elements of resilience as a supporting factor (Al Asyari, 2022) (Ilmi, 2019).

The rejection of the sixth hypothesis (H6) shows that learning style cannot moderate the effect of learning climate on students' mathematical reasoning in vocational schools. In the context of vocational high schools in Islamic boarding schools that restrict the use of mobile phones and technology, it shows limitations in the influence of learning styles as a mediator between learning climate and mathematical reasoning. In a certain environment, such as Islamic boarding schools, which tend to focus on traditional learning methods, the absence of technology makes it difficult for students to access resources that usually support visual, auditory, and kinesthetic learning styles (Rogowsky et al., 2020). With these restrictions, adapting to individual learning preferences becomes more difficult, which makes learning styles unable to significantly mediate the influence of learning climate on students' mathematical reasoning abilities (MAHAMA et al., 2021).

The learning climate in Islamic boarding schools that emphasizes values such as discipline and togetherness does support student engagement and task orientation. However, without technology, learning strategies are more limited to direct instruction from educators and interactions between students, which may not fully support various learning styles. Students with visual learning styles, for example, may have difficulty understanding abstract concepts without the help of visualizations that are usually supported by technology (MULYAWATI & US, 2023). It has an impact on their ability to develop mathematical reasoning, such as proposing conjectures and hypotheses and checking the validity of arguments (Al Asyari, 2022; Dan et al., 2024).

In this condition, support from educators becomes increasingly crucial. Without technology, educators must be more creative in delivering materials to accommodate various learning styles. However, research shows that without proper adjustments, students' learning styles will not be strong enough to mediate the effect of learning climate on mathematical reasoning (MAHAMA et al., 2021). More interactive approaches, such as problem-based learning, might become more effective in overcoming this limitation. But the particular study showed that learning styles still did not play a significant role as mediators.

Therefore, the rejection of this hypothesis emphasizes the importance of a more holistic approach to support mathematical reasoning in Islamic boarding schools. This approach should emphasize the development of critical and collaborative thinking skills rather than focusing on adapting to certain learning styles. In this context, strategies oriented towards conceptual exploration and social interaction, supported by existing local resources, are more relevant and effective in improving students' mathematical reasoning abilities (Al Asyari, 2022).

The seventh hypothesis (H7) obtained the results that learning styles can moderate the effect of mathematical resilience on the mathematical reasoning of students in vocational schools. It shows that learning styles (visual, auditory, and kinesthetic) play a significant role as mediating variables that moderate the effect of mathematical resilience on the mathematical reasoning of students in Islamic boarding schools. The educational environment of Islamic boarding schools, which emphasizes discipline, spirituality, and collective learning, influences the students to develop their learning styles (Wan Hussin & Mohd Matore, 2023). Visual learning styles help students understand mathematical concepts through visualization of diagrams or texts, which are often used in memorization and independent learning in Islamic boarding schools (Husein et al., 2022). Auditory learning styles support the reinforcement of

mathematical concepts through verbal interactions, such as group discussions or lectures, which are common teaching methods in Islamic boarding schools (Shannon Deonne Walton, 2010). Meanwhile, kinesthetic learning styles, although perhaps less common, can be integrated into practical activities such as experiments or physical activities that are often found in extracurricular programs (Setiana & Purwoko, 2020).

Indicators of mathematical resilience such as persistence, self-confidence, and resilience in facing challenges are very important for education in the environment of Islamic boarding schools. Persistence in dealing with mathematical problems, for example, can be developed through proper approaches to students' learning styles. Students with a visual learning style might use diagrams or pictures to solve a problem, while auditory students use discussions with teachers or peers to strengthen their understanding (Ishak et al., 2020). Students with a kinesthetic style may be more interested in hands-on practice or physical experiments that support their understanding of mathematical concepts (Yang & Wang, 2022).

The ability to communicate and work together in an Islamic boarding school environment also contributes to mathematical resilience. The auditory learning style is very much in line with the culture of Islamic boarding schools which encourages verbal interaction through activities such as group discussions, deliberations, and *tadarus* (reciting Al-quran). Auditory learners can improve their mathematical reasoning through verbal exchange of ideas and collaborative learning (Ghasemy et al., 2021). On the other hand, kinesthetic learners may benefit from collaborative activities involving physical interaction and object manipulation, leading to deeper understanding through hands-on experience (Sheromova et al., 2020). It shows the importance of integrating learning styles with contextual teaching methods in Islamic boarding schools which aims to support the development of students' mathematical reasoning effectively.

The ability to generate new ideas and find creative solutions to mathematical challenges also depends heavily on the learning style used by students. For example, visual learners in Islamic boarding schools may use diagrams or mind maps to develop new ideas, while auditory learners use discussions or lectures to overcome difficulties (Husein et al., 2022). Kinesthetic learners may prefer to find creative solutions through physical activities or experiments, which might be performed in group projects or contextual learning as a common practice in Islamic boarding schools (Sheromova et al., 2020).

Although the role of learning style as a mediating variable in the influence of mathematical resilience on mathematical reasoning is significant, its impact is relatively low, as indicated by the negative path coefficient value and low Upsilon V. The factor may be due to the presence of other stronger factors in the environment of Islamic Boarding School, such as spiritual support, community engagement, and a disciplined and holistic teaching approach. This study emphasizes the importance of an integrative approach that does not only focus on learning styles but also considers other contextual factors in optimizing students' mathematical resilience and reasoning in Islamic Boarding School (Ghasemy et al., 2021; Ozerem & Akkoyunlu, 2015). Therefore, a holistic learning strategy, which combines spiritual, social, and pedagogical aspects, is needed to support the development of students' mathematical abilities in Islamic Boarding School comprehensively.

CONCLUSION

Based on findings and discussion, it concluded that the first hypothesis (H1) shows a significant negative influence between learning styles and mathematical reasoning of students in vocational high school in Islamic boarding schools, with a path coefficient of -0.156, a t-

statistic of 2.230, and a p-value of 0.013. The second hypothesis (H2) shows a significant positive influence of learning climate on students' learning styles in vocational high schools, with a path coefficient of 0.190, a t-statistic of 2.492, and a p-value of 0.006. This conclusion indicates that improving the learning climate contributes to improving students' learning styles. The third hypothesis (H3) states that the learning climate does not have a direct influence on the mathematical reasoning of students in vocational high schools in Islamic boarding schools. Moreover, factors such as student involvement, student affiliation, educator support, task orientation, and competition in learning do not significantly affect students' ability to mathematical reasoning. The fourth hypothesis (H4) shows a significant positive influence of mathematical resilience on the learning styles of students in vocational high school and highlights the importance of the affective aspect in training students' learning approaches. The rejection of the fifth hypothesis (H5), that mathematical resilience does not have a significant effect on the mathematical reasoning of students in vocational high school in Islamic boarding schools highlights the special challenges in this environment due to the practice of the restricted use of cellphones and technology. The rejection of the sixth hypothesis (H6) shows that learning styles cannot moderate the influence of learning climate on the mathematical reasoning of students in vocational high schools. In the context of vocational high schools in Islamic boarding schools that do not allow the use of cellphones and technology, it found limitations in the influence of learning styles as a mediator between learning climate and mathematical reasoning. The seventh hypothesis (H7) obtained results that learning styles can moderate the influence of mathematical resilience on the mathematical reasoning of students in vocational high schools. This shows that learning styles (visual, auditory, and kinesthetic) play a significant role as mediating variables to moderate the influence of mathematical resilience on students' mathematical reasoning in Islamic boarding schools.

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