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The Relationship Between Mathematical Critical Thinking Ability and Students' Political Literacy in Senior High School

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ABSTRACT

Critical thinking and political literacy are essential competencies in 21st-century education; however, they are often developed separately in school learning. This study investigates the relationship between mathematical critical thinking ability and students' political literacy at the senior high school level. Using a quantitative correlational design, data were collected from 80 eleventh-grade students selected through stratified random sampling from three public high schools in Yogyakarta City. The instruments consisted of a mathematical critical thinking test and a political literacy questionnaire, both of which demonstrated acceptable validity and reliability. Data were analyzed using the Pearson Product–Moment correlation. The results revealed a significant positive correlation between mathematical critical thinking and political literacy ($r = 0.58$, $p < 0.01$), indicating that students with stronger mathematical reasoning tend to exhibit higher political literacy, including a better understanding of democratic values and more rational civic attitudes. These findings demonstrate that mathematical critical thinking contributes meaningfully to students' political literacy. The study highlights the importance of integrating socio-political contexts into mathematics instruction as an interdisciplinary approach to fostering analytical and responsible citizenship in a democratic society.

Keywords
Critical Thinking Skills
Democratic Society
High School Students
Political Literacy

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Introduction

Education in the 21st century demands students to master a set of higher-order thinking skills known as the 4Cs: critical thinking, creativity, communication, and collaboration. Among these, critical thinking plays a central role as it enables individuals to analyze information, evaluate arguments, and make rational decisions based on evidence [1]. In the context of mathematics education, critical thinking is not limited to computational skills; rather, it emphasizes reasoning, problem-solving, and the ability to apply abstract concepts in real-world contexts [2]. Mathematical problems often require logical inference, argumentation, and evaluation of quantitative data, all of which contribute to the development of critical thinking dispositions that are transferable beyond mathematics itself [3] At the same time, the development of political literacy is increasingly recognized as an essential outcome of modern education. Political literacy refers to an individual's knowledge, awareness, and understanding of political systems, democratic values, and civic responsibilities [4]. In a democratic society, political literacy empowers citizens to participate actively and responsibly in governance processes, including elections, public deliberation, and policy evaluation. In the school context, strengthening students' political literacy is not only a civic objective but also a means to cultivate critical reasoning toward political information, particularly in the digital era where misinformation and polarization are prevalent.

However, empirical evidence shows that both critical thinking and political literacy among Indonesian students remain relatively low. The PISA 2022 results reveal that Indonesian students' mathematical reasoning and problem-solving skills lag behind the OECD average, indicating weaknesses in analytical and evaluative thinking. Similarly, the Indonesian General Elections Commission [5] reports that the level of political awareness and participation among first-time voters most of whom are high school students is still limited, with many exhibiting low understanding of democratic principles and political institutions. This suggests that schools have not yet optimized their role in fostering students who are both critically minded and politically literate.

Given that both mathematical critical thinking and political literacy rely on reasoning, evidence evaluation, and decision-making, it is plausible that these two competencies are interrelated. Mathematics provides a structured context for training logical and analytical thinking, which can in turn enhance one's ability to interpret political information objectively and rationally. Integrating socio-political contexts such as election data, opinion surveys, and demographic statistics into mathematics learning can potentially enrich students' understanding of both mathematics and democracy.

Previous studies have examined the role of critical thinking in promoting civic engagement and political understanding [6] [7], yet few have specifically investigated

mathematical critical thinking as a contributing factor to political literacy among high school students. This indicates a gap in the literature and underscores the need for interdisciplinary research bridging mathematics education and civic education.

Therefore, this study aims to explore the relationship between mathematical critical thinking and students' political literacy in Indonesian high schools. By identifying whether mathematical reasoning skills correlate with political understanding, this research seeks to provide empirical evidence supporting the integration of cognitive and civic competencies in educational practice. The study hypothesizes that there is a positive and significant relationship between mathematical critical thinking ability and students' political literacy.

This article is organized as follows. The next section presents the research methodology, including the research design, participants, instruments, and data analysis techniques employed in the study. The subsequent section reports the research findings, focusing on the statistical relationship between mathematical critical thinking ability and students' political literacy. These results are then discussed in relation to relevant theoretical perspectives and previous studies to highlight their educational implications. Finally, the article concludes by summarizing the key findings and outlining recommendations for interdisciplinary instructional practices and future research.

Material and Methods

This study employed a quantitative correlational design to examine the relationship between students' mathematical critical thinking ability and their political literacy. The correlational approach was selected because it enables the identification of the strength and direction of the relationship between two variables without the application of treatment or manipulation, making it appropriate for obtaining empirical evidence regarding the association between cognitive skills and civic competencies at the secondary education level.

The participants comprised 80 eleventh-grade students from SMA Negeri 1 Adiluwih, Pringsewu Regency, Lampung Province, during the 2024/2025 academic year. The sample included 40 students from the Natural Sciences Program (NSP) and 40 students from the Social Sciences Program (SSP), selected using a stratified random sampling technique to ensure balanced representation from both academic programs. All participants had completed compulsory mathematics courses as well as Pancasila and Civic Education (*Pendidikan Pancasila dan Kewarganegaraan* or PPKn), which are relevant to the development of political literacy.

Data were collected using two main instruments. The first instrument was the Mathematical Critical Thinking Test (MCTT), consisting of 10 open-ended essay questions developed based on Ennis's indicators of critical thinking, including interpretation, analysis, evaluation, inference, and explanation. The items were contextualized within mathematical

topics such as statistics and data interpretation and were linked to social and political issues. The second instrument was the Political Literacy Questionnaire (PLQ), comprising 30 statements measured on a five-point Likert scale and covering the cognitive, affective, and behavioral dimensions of political literacy.

The content validity of both instruments was evaluated by three education experts to ensure the appropriateness of the indicators and the clarity of the items. Reliability testing yielded Cronbach's Alpha coefficients of 0.82 for the mathematical critical thinking test and 0.87 for the political literacy questionnaire, indicating high internal consistency. Both instruments were also pilot-tested with students outside the research sample prior to the main data collection.

The research procedure consisted of three main stages: preparation, data collection, and data analysis. During the preparation stage, coordination with the school was conducted and ethical approval for the study was obtained. Data collection involved administering the mathematical critical thinking test, followed by the political literacy questionnaire within the same session. The collected data were then analyzed using the Pearson Product–Moment correlation coefficient to determine the strength and direction of the relationship between the variables. Prior to the correlation analysis, assumption tests for normality and linearity were performed. The level of significance was set at $\alpha = 0.05$, and the interpretation of correlation strength followed Cohen's criteria.

This study has several limitations. First, the sample was drawn from a single school, which limits the generalizability of the findings. Second, the sample size was relatively small and may not adequately represent variations across broader school contexts. Third, political literacy was measured using a self-report instrument, which may be subject to social desirability bias. Therefore, future research is recommended to involve multiple schools, larger sample sizes, and longitudinal designs to examine causal relationships more comprehensively.

Results

Data collected from 80 students were analyzed using the *Pearson Product Moment* correlation test to examine the relationship between mathematical critical thinking and political literacy. Prior to hypothesis testing, assumption tests were conducted. The *Kolmogorov Smirnov* test indicated that both variables were normally distributed ($p > 0.05$), and the linearity test confirmed a linear relationship between the variables ($F = 21.37$, $p < 0.01$), thus fulfilling the requirements for correlation analysis. To provide a clearer and more meaningful interpretation, the results of the Mathematical Critical Thinking Test were analyzed and presented based on critical thinking indicators rather than individual test items. These indicators included interpretation, analysis, evaluation, inference, and reasoning.

Descriptive analysis across indicators showed that students achieved moderate to high mean scores on most components, with particularly strong performance in analysis and inference, indicating an adequate ability to identify relationships, process information logically, and draw conclusions from mathematical data. The overall mean score for mathematical critical thinking was 27.45 (*SD* = 5.21) on a scale of 0–40, which reflects a moderate to high level of mathematical reasoning ability. For clarity, the distribution of students' achievement across indicators is illustrated using comparative charts. Therefore, a comparative chart is used to illustrate the variation in students' achievement across the indicators of mathematical critical thinking, as shown in Fig. 1.

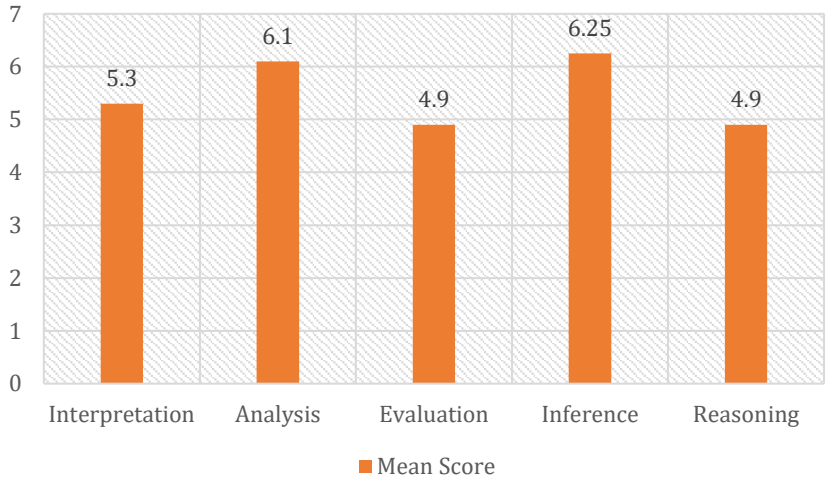


Fig 1. Mean score of the Mathematical Critical Thinking Indicator

Fig. 1 illustrates the distribution of students' mathematical critical thinking skills across five indicators: interpretation, analysis, evaluation, inference, and reasoning. Overall, the graph shows that students achieved moderate to high mean scores on all indicators, indicating a relatively balanced development of critical thinking skills in mathematical contexts. The highest mean scores were observed in the analysis and inference indicators, suggesting that most students are able to identify relationships among mathematical concepts, process information logically, and draw conclusions based on given data. This finding indicates that students are generally proficient in breaking down mathematical problems and formulating reasonable conclusions. Meanwhile, the interpretation indicator also demonstrated a high mean score, reflecting students' ability to understand mathematical representations such as symbols, tables, and graphs.

In contrast, the evaluation and reasoning indicators showed comparatively lower mean scores, although they remained within the moderate category. This suggests that while students are capable of solving problems, they experience more difficulty when required to critically assess the validity of arguments, justify solution strategies, or evaluate the correctness of alternative approaches. These results highlight the need for instructional

strategies that emphasize argumentation, justification, and reflective thinking in mathematics learning. Given that these higher-order reasoning skills are also central to students' engagement with social and civic information, the analysis was extended to examine students' political literacy profiles.

Building on these findings, political literacy data were not reported solely as aggregate scores but were further organized according to conceptual indicators of political literacy to enhance interpretability. The mean score for political literacy was 102.73 (SD = 12.14) on a scale of 30–150, suggesting that students generally demonstrated a good level of understanding of political concepts, democratic values, and civic responsibilities. Indicator-based visualization highlights relative strengths and weaknesses among components of political literacy, allowing for more nuanced interpretation. Table 1 presents the summary of descriptive statistics and the correlation results between mathematical critical thinking and political literacy. Similarly, political literacy data were not reported solely as aggregate scores but were further organized according to conceptual indicators of political literacy to enhance interpretability. The mean score for political literacy was 102.73 (*SD* = 12.14) on a scale of 30–150, suggesting that students generally demonstrated a good level of understanding of political concepts, democratic values, and civic responsibilities. Indicator-based visualization highlights relative strengths and weaknesses among components of political literacy, allowing for more nuanced interpretation. Table 1 presents the summary of descriptive statistics and the correlation results between mathematical critical thinking and political literacy.

Table 1. The descriptive and correlational data.

Variable	Mean	SD	r	Sig. (p)	Interpretation
Mathematical Critical Thinking	27.45	5.21	0.58	0.000	Moderate to High
Political Literacy	102.73	12.14			Significant Positive

Table 1 is the descriptive statistics and correlation result between Mathematical Critical Thinking and Political Literacy (n = 80). The Pearson correlation coefficient was r = 0.58 with $p < 0.01$, indicating a strong and statistically significant positive relationship between mathematical critical thinking and political literacy among students. This finding suggests that students who demonstrate higher levels of mathematical critical thinking characterized by the ability to analyze problems systematically, evaluate evidence, draw logical conclusions, and make reasoned judgments also tend to exhibit greater political literacy. Political literacy in this context includes an understanding of political structures, democratic principles, civic engagement, and the ability to make informed decisions regarding social and governmental issues.

In other words, as students enhance their capacity to think critically in mathematical contexts, such as interpreting data, identifying underlying assumptions, and applying logical

reasoning to solve complex problems, they simultaneously strengthen the cognitive skills required to comprehend political processes and societal dynamics. This relationship may be explained by the fact that both domains mathematical critical thinking and political literacy rely heavily on analytical reasoning, evidence-based evaluation, and reflective judgment. The statistically significant correlation ($p < 0.01$) underscores the robustness of this association, implying that improvements in one domain could potentially foster growth in the other. Consequently, educational practices that promote critical thinking through mathematics instruction may have broader benefits, contributing not only to academic achievement but also to the cultivation of informed, reflective, and participatory citizens. To gain a more detailed understanding of students' political literacy, the construct was further analyzed across three domains: cognitive, affective, and behavioral for both NSP and SSP tracks. The results are summarized in Table 2.

Table 2. Mean Scores of Political Literacy by Domain and Academic Track

Doamain	NSP	SSP	Total Mean	Interpretation
Cognitive	3.72	3.95	3.84	High
Affective	3.58	3.89	3.73	High
Behavioral	3.41	3.67	3.54	Moderate to high
Overall Political Literacy	3.57	3.84	3.70	High

Scale: 1.00–1.80 = Very Low; 1.81–2.60 = Low; 2.61–3.40 = Moderate; 3.41–4.20 = High; 4.21–5.00 = Very High

The results in Table 2 indicate that both groups demonstrated relatively high levels of political literacy across all domains, with SSP students consistently scoring higher than their NSP counterparts. The largest mean difference appeared in the cognitive domain ($\Delta M = 0.23$), suggesting that students from the social science track possess a stronger understanding of political systems, democratic principles, and civic responsibilities. Meanwhile, the affective domain also showed a notable difference ($\Delta M = 0.31$), implying that SSP students tend to display more positive attitudes toward civic engagement, tolerance, and democratic participation. In contrast, the behavioral domain recorded the lowest mean scores for both groups, indicating that while students possess sufficient knowledge and attitudes, these are not yet fully reflected in active participation or civic behaviors. Overall, the total mean of 3.70 (on a 5-point scale) places students' political literacy in the "high" category, confirming that secondary education incorporating civic and mathematical reasoning components may effectively support students' development as informed citizens.

Discussions

A. Mathematical Critical Thinking as a Cognitive Foundation for Political Literacy

The findings of this study demonstrate a statistically significant relationship between mathematical critical thinking and students' political literacy. This relationship suggests that the cognitive processes cultivated in mathematics classrooms extend beyond disciplinary

boundaries and contribute to broader civic competencies. Mathematical critical thinking involves reasoning, logical evaluation, and systematic interpretation of quantitative information. These intellectual processes enable students to approach political information in a more structured and analytical manner.

Students with stronger mathematical reasoning skills tend to demonstrate greater capacity for evaluating arguments, interpreting statistical claims, and questioning the credibility of information sources. Such skills are particularly important in contemporary democratic societies where political discourse increasingly relies on quantitative evidence, data visualization, and statistical narratives. As a result, mathematical thinking becomes an essential epistemic tool for navigating complex civic information environments.

This finding corroborates Rahmawati's research [6], which indicates that students' critical reasoning abilities significantly influence their capacity to interpret political phenomena objectively. The theoretical foundation for this relationship is also supported by Ennis [7] and Facione [8], who argue that critical thinking cultivates intellectual virtues such as reflective judgment, fairness in reasoning, and openness to alternative perspectives. These qualities are fundamental for responsible democratic participation.

Recent scholarship further conceptualizes this relationship through the notion of *quantitative civic literacy*, which emphasizes the role of numerical reasoning in public communication and civic engagement [15]. Citizens must increasingly interpret statistical information related to elections, economic policy, and public health. Consequently, mathematical reasoning functions not merely as a technical skill but as a civic competency necessary for informed participation in democratic decision-making.

Moreover, Geiger, Gal, and Graven [16] argue that mathematics education has gradually evolved toward incorporating social and civic dimensions, particularly through the development of critical numeracy and statistical literacy. Their work suggests that mathematics classrooms can serve as important spaces for developing analytical citizenship. From this perspective, the observed relationship between mathematical critical thinking and political literacy in this study reflects a broader transformation in the role of mathematics education in democratic societies. This transformation highlights the potential of mathematics learning to empower students with the analytical tools necessary to critically engage with public information, policy debates, and evidence-based decision making.

However, it is important to note that mathematical thinking alone does not fully determine students' political literacy. Civic awareness also emerges from social experiences, cultural contexts, and exposure to political discourse. Therefore, the relationship identified in this study should be interpreted as part of a broader ecosystem of factors that shape civic competence.

B. Contextualised Mathematics Learning and the Development of Civic Awareness

Another important finding of this study concerns the role of contextualised mathematics instruction in promoting students' engagement with political issues. Classroom observations indicated that students became more interested in political topics when mathematical concepts were presented through real-world data, such as election statistics, demographic information, or public budgeting figures. This suggests that contextual learning environments may function as effective bridges between abstract mathematical reasoning and concrete societal issues.

This observation aligns with the work of Harper and Kudaisi [9], who demonstrate that embedding mathematics within social justice contexts enhances both engagement and critical awareness. By analyzing real-world data related to social inequalities, environmental issues, or political participation, students develop the capacity to apply mathematical reasoning to societal problems. Similarly, Rico et al. [10] show that integrating data interpretation and argumentation in mathematics and science education can foster students' understanding of democratic participation.

The moderate-to-strong correlation identified in this study ($r = 0.58$) indicates that mathematical critical thinking contributes meaningfully to students' political literacy, although it is not the sole determining factor. Civic engagement opportunities within educational settings also play a crucial role in shaping students' understanding of social and political issues. Ahrari et al. [11] emphasize that civic participation experiences in schools significantly strengthen students' critical thinking and social responsibility.

In addition, Bredberg [12] highlights the democratic potential of mathematics education by arguing that quantitative reasoning enables individuals to interpret societal data and evaluate policy claims. Wardana [13] similarly notes that mathematical thinking involves reasoning, justification, and contextual application rather than mere computational procedures. These perspectives reinforce the idea that mathematics education can contribute to civic literacy when it emphasizes interpretation and critical analysis.

Recent studies provide further empirical support for this argument. For instance, research on civic-oriented mathematics instruction shows that students who engage with quantitative representations of political phenomena develop stronger analytical reasoning skills and greater awareness of democratic processes [17]. Likewise, interdisciplinary approaches combining mathematics and civic education have been shown to improve students' ability to evaluate public claims and participate in evidence-based discussions about societal issues [18].

These findings collectively suggest that contextualised mathematics instruction can function as a powerful pedagogical strategy for integrating cognitive development with civic education.

C. Educational Implications and Future Directions for Civic-Oriented Mathematics Education

The findings of this study carry several important implications for pedagogy, curriculum development, and educational policy. From a pedagogical perspective, mathematics instruction should move beyond procedural problem-solving toward learning environments that emphasize inquiry, argumentation, and real-world interpretation. Inquiry-based mathematics instruction has been shown to encourage deeper conceptual understanding and the transfer of analytical reasoning across disciplinary domains [14].

Curriculum development also plays a crucial role in enabling this transformation. Interdisciplinary learning frameworks that integrate mathematics with civic and social studies education can provide students with opportunities to apply quantitative reasoning to societal challenges. Romero-Ariza et al. [1] argue that such integrative frameworks are particularly relevant for contemporary educational reforms that emphasize critical thinking, learner autonomy, and civic responsibility.

Within the Indonesian educational context, this approach resonates strongly with the goals of the *Profil Pelajar Pancasila*, which emphasizes critical reasoning, democratic participation, and social responsibility. Integrating mathematical reasoning with civic education may therefore contribute to the development of students who are not only academically competent but also socially responsible and politically aware.

Research in democratic mathematics education further suggests that classrooms can become spaces where students develop both conceptual understanding and civic consciousness simultaneously [19]. By engaging students in discussions about real-world data and policy issues, mathematics teachers can cultivate habits of evidence-based reasoning that mirror the practices of democratic deliberation.

Policy-level coordination between mathematics educators and civics teachers may also strengthen these outcomes. Cross-disciplinary collaboration allows students to explore societal challenges through both qualitative and quantitative perspectives, thereby enhancing their ability to interpret complex political information [21]. Studies on democratic classroom practices indicate that such interdisciplinary approaches can foster active citizenship and critical awareness among students [22].

Another important dimension concerns the growing role of digital media in shaping political knowledge. In the digital era, citizens encounter vast amounts of statistical information, infographics, and data-driven claims through online platforms. Consequently, mathematical literacy must increasingly be integrated with digital and media literacy. Research on civic online reasoning demonstrates that individuals require strong analytical skills to evaluate the credibility of online information and distinguish reliable data from

misinformation [23]. Scholars of media literacy similarly emphasize the importance of developing critical evaluation skills in information-rich digital environments [24], [25].

Despite its contributions, this study has several limitations. First, the research sample was limited to a single school in Pringsewu Regency, which restricts the generalizability of the findings. Second, the correlational design does not allow causal relationships to be established between mathematical thinking and political literacy. Third, the measurement of political literacy relied on self-reported responses that may be subject to social desirability bias. Finally, potential mediating variables such as socio-economic background, civic experiences, and instructional practices were not included in the analysis.

Future research should address these limitations by employing larger and more diverse samples across multiple educational contexts. Longitudinal and experimental research designs may provide deeper insights into the causal mechanisms linking mathematical education and civic outcomes. In addition, qualitative methods such as classroom observation and student interviews could illuminate how specific mathematical learning activities foster civic reasoning and political awareness. Investigating the role of digital media literacy as a moderating variable may also provide valuable insights into how students interpret quantitative political information in the digital age.

Conclusion

This study reveals a significant positive relationship between mathematical critical thinking ability and students' political literacy among eleventh-grade students at SMA Negeri 1 Adiluwih. The findings indicate that students with stronger mathematical reasoning skills tend to demonstrate higher levels of political understanding, democratic awareness, and civic responsibility. This result underscores that the cognitive processes developed through mathematical learning such as analysis, evaluation, and inferenceare meaningfully associated with students' ability to engage with political information rationally. The study highlights the educational implication that mathematics instruction, when connected to socio-political contexts, can contribute to the development of both cognitive and civic competencies. These findings support the adoption of interdisciplinary learning approaches that integrate mathematical reasoning with real-world issues to foster critical and responsible citizenship. Overall, the study confirms that mathematical critical thinking and political literacy are interconnected competencies, emphasizing the importance of curriculum designs that bridge academic skills and civic education.

Conflict of Interest

There is no conflict of interest.

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