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An ex post facto study of critical thinking skills in mathematics learning based on school geography

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Abstract

Background: Educational disparities in Indonesia necessitate a comprehensive evaluation of students' critical thinking skills across various geographical regions, including highlands, border areas, and lowlands, to address potential educational shortcomings.
Aim: The study aims to quantitatively assess and compare the mathematical critical thinking abilities of junior high school students across different geographical settings to inform educational strategies and interventions.
Method: Employing a quantitative approach with an ex post facto causal comparative research design, the study utilized cluster sampling to select a representative sample of 82 students from highland, border, and lowland schools. Descriptive and inferential statistical analyses, including Kruskal-Wallis tests and post hoc examinations, were conducted to analyze the data.
Result: Preliminary descriptive analysis indicated a general lack of critical thinking skills in mathematics among students in all areas. However, inferential statistical analysis revealed significant differences in the critical thinking abilities of students from the three geographical regions, with students in urban (lowland) areas displaying superior critical thinking rankings compared to their counterparts in border and rural (highland) areas.
Conclusion: The findings underscore significant geographical disparities in mathematical critical thinking skills among Indonesian junior high school students. These disparities are likely influenced by factors such as unequal access to educational resources, teaching methodologies, student interest, and the socioeconomic and educational backgrounds of parents. Addressing these inequalities is crucial for enhancing the educational outcomes and critical thinking abilities of students across Indonesia.

INTRODUCTION

Several international organizations and academics have proven that students must have 21st-century skills that are urgently needed for the growth and implementation of active and creative citizenship (Silva et al., 2023), one of which is the ability to think critically (OECD, 2018; Setiawati et al., 2021). A man of today should be able to evaluate the received information and determine its trustworthiness, reliability, usefulness, etc (Pavlova et al., 2019). Citizens with critical and creative thinking skills are better able to solve complex situations, and take responsibility for their actions (OECD, 2018). This shows that someone with good critical thinking skills will be able to face the challenges of life and career problems in a world characterized by accelerating change and increasing complexity (Paul, 1995; Setiawati et al., 2021).

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Critical thinking as the ability to analyze information from the standpoint of logic and the personal psychological approach to apply the results to both standard and non-standard situations and issues (Pavlova et al., 2019). Critical thinking is the ability to raise new questions, develop diverse arguments, and sound decision-making (Paul, 1995). The ability to think critically is a basic capital or intellectual capital for everyone and an important skill for students at all levels of education (Setiana et al., 2021; Triani et al., 2023). Critical thinking in education has been a focus of attention in research and pedagogy for over 100 years. Emphasised by John Dewey as an educational goal, Dewey proposed that developing critical thinking would empower students to become fair-minded and democratic members of society (Dewey, 1933).

Critical thinking in education has been a focus of attention in research and pedagogy for over 100 years (O'Reilly et al., 2022). Emphasised by John Dewey as an educational goal, Dewey proposed that developing critical thinking would empower students to become fair-minded and democratic members of society (Dewey, 1933). Through thinking skills, originality of ideas and flexibility in finding solutions to the problems faced, students will be able to think rationally and thoroughly to complete the assigned tasks. Students who think critically can understand problems well, make problem-solving plans and solve mathematical problems in different ways (Angraini & Wahyuni, 2021).

Students' critical thinking skills need to be developed through a meaningful learning process that encourages students to think systematically, analytically, evaluatively and logically in order to make a decision when solving problems. Mathematics, as a field of science, certainly provides many opportunities for students to develop critical thinking skills. In addition, Mathematics requires a process for students to think critically, namely thinking to test, question, connect, evaluate all aspects that exist in a situation or problem that triggers it (Angraini & Wahyuni, 2021).

In Indonesia, students' mathematical critical thinking skills are still relatively low (Farib et al., 2019). This fact is supported by the results of a study conducted between 2017 and 2022 at the primary, junior high, and senior high school levels, which found that students' average mathematical critical thinking skills are low (Anggraini et al., 2022; Benyamin et al., 2021; Danaryanti & Lestari, 2018; Dores et al., 2020; Irawan et al., 2017; Septiana et al., 2019). Anggraini et al (2022) research showed that the distribution of critical thinking skills in geometry, algebra and possibilities with 30 junior high school students were still low with a score of 31.42. The results of Benyamin et al (2021) research showed that students' critical thinking skills on SPLTV material with 31 high school students were still low. The results of another study by Danaryanti & Lestari (2018) showed that students' critical thinking skills, especially on the indicator of analysing arguments in mathematics material, were still low. They used 464 junior high school students as their research sample. Unlike other studies, Dores et al (2020) used 15 primary school students as their research sample. The test results showed that the average critical thinking skills of the students were still low. The results of Irawan et al (2017) research show that the average critical thinking skills of junior high school students are still low, with an average score of 44.87 on each indicator of critical thinking skills. Irawan (2017) used 31 research subjects. The same results were shown by Septiana et al (2019) research with 10 junior high school students that the students' critical thinking skills were still very low. All researchers used test instruments and some used interview sheets to collect data.The results of this study indicate that students' mathematical critical thinking skills are not optimally developed at school (Angraini & Wahyuni, 2021; Farib et al., 2019).

Low levels of critical thinking skills are influenced by a number of external factors. External factors include teachers, learning tools, learning methods or strategies and schools. The role of school as a place for the development of different knowledge and skills of students plays an important role in the achievement of different mathematical skills. Schools must organise education that is able to develop the character of students who think critically in order to adapt to the 21st century (Setiana et al., 2021). There are many studies in Indonesia that examine the influence of various external factors on students' mathematical critical thinking skills, but there is no research that examines how the school environment based on the geographical location of the school affects students' critical thinking skills.

The geographical location of schools is a factor that is often overlooked in the study of mathematics achievement. School location is one of the variables that has a significant relationship with students' mathematics achievement (Pangeni, 2013). In his study, Pangeni used 762 students in Nepal from 21 secondary schools from three ecological zones (mountains, hills and lowlands). The results showed that school characteristics are one of the factors that affect mathematics learning achievement. However, based on data from 29 developed and developing countries, found that the overall proportion of variance in student achievement was largely associated with school characteristics as compared to student background characteristics particularly in less industrialised countries and that ‘‘the predominant influence student learning is the quality of schools and teachers to which children are exposed’’ (Heyneman & Loxley, 1983).

In fact, schools in urban, border and rural areas are often treated differently by the government in terms of facilities and accessibility, depending on their respective regional budgets. The existence of flagship or favoured schools with special coaching and treatment orientation results in all resources being given to these schools (Kemendikbud, 2018). In addition, there is a disparity factor, which is the difference or inequality of educational outcomes in society, which affects the inequality of school infrastructure, availability and competence of teachers between regions, especially underdeveloped regions (Anwar et al., 2019). Parental financial factors and the different characteristics of individuals in cities and villages are also very influential. Parents living in rural areas will have different ideas from those living in border and urban areas. Many rural parents do not understand the importance of education. Most parents in rural areas work in agriculture, farming and some do not have regular jobs. This condition affects their thinking and limits their ability to provide better education for their children. This is a common phenomenon in Indonesia.

The geographical factor of schools is one of the factors that needs to be studied for its influence on the quality of education, in this case students' mathematical skills. Until now, in Indonesia, there has been no research on the effect of school geography on students' mathematical abilities. Researchers want to know the extent to which geographical location factors can affect the achievement of students' academic abilities, particularly students' critical thinking skills in mathematics subjects. This study aims to investigate the mathematical critical thinking skills of students with different school geographical locations.

There are different approaches to critical thinking (Pavlova et al., 2019), as there are many definitions of it. The concept of critical thinking more broadly by referring to it as reflective thinking (Dewey, 1910). Critical thinking refers to students putting their previous knowledge into practice and to changing their preliminary knowledge by giving valuing their own thoughts (Norris, 1985). In another hand, critical thinking as a disciplined and self-directed learning process exemplifying the perfections of thinking in accordance with a specific type or field of critical thinking (Paul, 1995). As other skills, critical thinking skills can also be taught, learned, and developed through formal or non-formal learning process and use in daily life. One of the fields, in which critical thinking skills can be effectively used, is mathematics (Arisoy & Aybek, 2021).

Critical thinking skills can be developed through the process of learning mathematics. Improving critical thinking skills in mathematics learning is crucial for students to develop problem-solving abilities and analytical thinking. Mathematics teachers play a significant role in fostering critical thinking skills among their students. The process of critical thinking in learning mathematics can be facilitated by presenting non-routine and open-ended contextual problems based on students' prior knowledge (Setiana, et al., 2019). Mathematical critical thinking is the ability to conceptualise, apply, analyse, synthesise and evaluate information obtained from observation, experience and reflection in order to make a correct and rational decision based on supporting evidence or reasons, to reach a reliable conclusion in believing and doing something to solve a mathematical problem. The indicators of critical thinking skills used in this study are (1) providing basic explanations; (2) building basic skills; (3) concluding; (4) providing further explanations; and (5) organising strategies and tactics (Ennis, 1987).

Within the context of Indonesia, although numerous studies have investigated the impact of various external factors on students' mathematical critical thinking abilities, there has yet to be research specifically exploring how the geographical locations of urban, border, and rural schools affect these abilities. The novelty of this study lies in its unique focus on geographical influence as a determining factor in the development of Indonesian students' mathematical critical thinking skills. By understanding how the geographical location of schools interacts with mathematics learning and the development of critical thinking abilities, this research aims to fill this knowledge gap and provide recommendations that can aid in designing more inclusive and effective educational policies. Therefore, this study not only contributes to the field of mathematics education but also to efforts aimed at improving the overall quality of education in Indonesia.

METHODS

Design

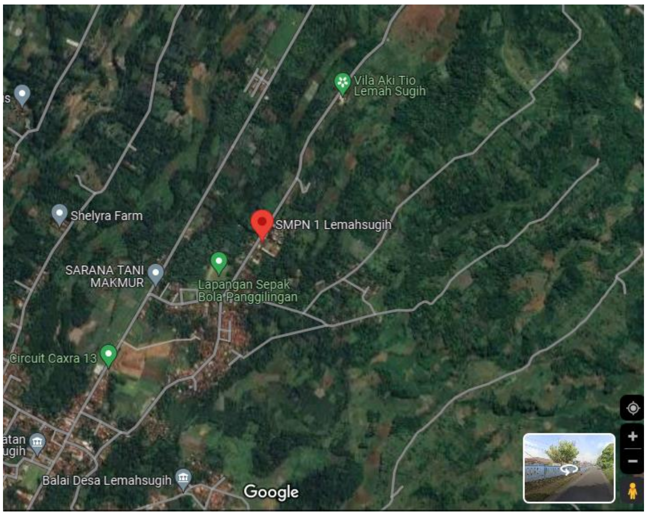
This research is a quantitative research with ex post facto casual comparative research method. This study examines the comparison of mathematical critical thinking skills of junior high school students based on test scores in three different schools based on geographical location, namely highland (rural), border and lowland (urban). The lowland area in Majalengka Regency, Indonesia, includes only urban areas as there are no coastal areas.

Participants

The popolation in this study are 138 secondary schools in Majalengka, 111 schools in lowland areas, 8 schools in border areas and 19 schools in highland areas. One school in each region was randomly selected as the research sample. The research sample used cluster sampling, selecting three clusters from the population: highlands, borders and lowlands. The participants of these research were 82 students, 32 students from highland (rural) schools, 25 students from border schools and 25 students from lowland (urban) schools. The students who became the research subjects were the students who had received materials on flat surfaces as the given test materials. The sampling technique used was cluster random sampling with three defined regional groups. This technique is used in a very large population, namely the area of Majalengka district. Geographically, the three schools used as research samples have different regional characteristics.

Table 1. Geographical Location of The School

Geographical location	School Name	Description
Highland School	School A	Located in the village of Majalengka Regency. The school is located far from the town centre, including the highland hills at the foot of Mount Cakrabuana. The location of this school is prone to disasters, both earthquakes and erosion disasters, so the condition of the building needs to be stable. The distance between the school and the city centre is 36.2 km.



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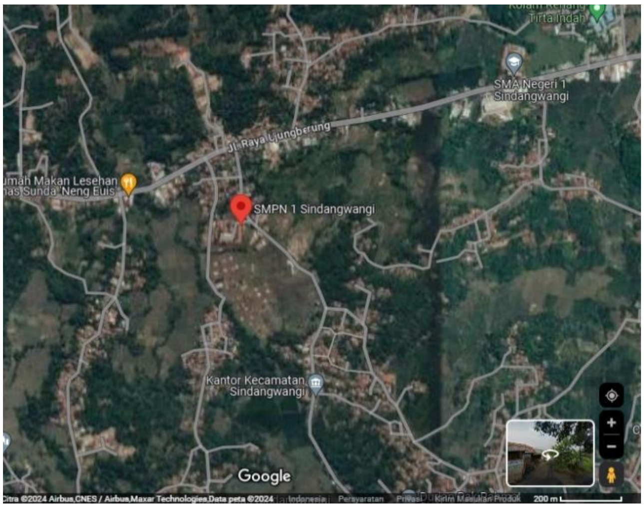
Geographical location	School Name	Description
Border School	School B	Located on the border between the towns of Majalengka and Cirebon. The distance from the school to the city centre is 19.9 km



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Lowland School	School C	Located in the town centre of Majalengka, 1.9 km from the town centre. This school is a popular secondary school as a pilot international standard school in 2004 - 2012 and currently as a child-friendly school.

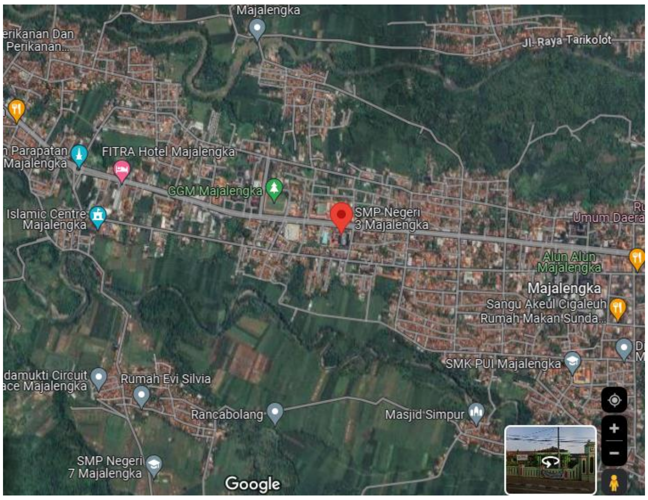

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Table 1 gives an overview of the geographical conditions of the three schools in the sample. Geographically, school A is far from the city centre and has a disaster-prone area. School B is located on the border between town and village. School B is flanked by two big cities, Cirebon and Majalengka, while School C is in the city centre and far from the countryside.

Instrument

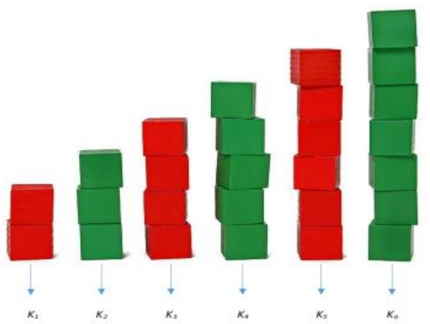
The instrument used to collect data was a test with indicators of critical thinking skills on cube and block material and interview questionnaires for teachers and students. All research participants were subjected to the test, which was designed to assess their understanding of flat-sided space building materials, such as cubes and cuboids. Abbreviations were explained on their initial use. The test contained mathematical problems with five indicators of mathematical critical thinking skills from (Ennis, 1989).

Table 2. Indicators of Mathematical Critical Thinking (IMCT)

IMCT1 Elementary Clarification	:	Identifying the sufficiency of data to solve problems involving the area of a block.
IMCT2 Basic support	:	Identify the concepts involved in solving problems relating to the area of a solid.
IMCT3 Inference	:	Infer analogies and generalisations related to the number of stacks of cubes in the *n*th pattern
IMCT4 Advance Clarification	:	Prove the correctness of a statement about the area of blocks
IMCT5 Strategies and Tactics	:	Finding alternative solutions that are more efficient than cubes and blocks.

One of the test instruments used with IMCT3 is shown in the following question.

Consider the following row of stacked cubes!



The area of the block (cube) in the nth pattern (kn) is calculated.

Problem:

If the process of stacking cubes is continuous up to the nth (kn) pattern, which pattern will you use to determine it? Find the formula for the area of a block in the nth (kn) pattern.

Figure 3. Test instrument on IMCT3

Data Analysis

In terms of data analysis techniques, descriptive statistics and inferential statistics were used. Descriptive statistics such as mean, frequency, percentage were calculated and presented in tabular form. These descriptive data were used to see the level of mathematical critical thinking skills of students in geographically different schools through test scores given without treatment. Inferential statistics, such as the *Kruskal-Wallis* test, were used to see the comparison of critical thinking skills between students in the three regions. This test was used because the critical thinking data of the three groups (urban, border and rural) were not normal. *Post-Hoc* follow-up tests were carried out to see if there were significant differences between two schools in three different regions. To standardize the results, the classification of critical thinking ability levels from (Susilo, 2020) were adapted by the researchers.

Table 4. Presents the Classification of Students' Mathematical Critical Thinking Ability.

Interval Skor	Classification of Mathematical Critical Thinking Abilities
$3{,}2 < \bar{x} \leq 4{,}0$	Very Critical
$2{,}6 < \bar{x} \leq 3{,}2$	Critical
$2{,}2 < \bar{x} \leq 2{,}6$	Moderatly Critical
$1{,}6 < \bar{x} \leq 2{,}2$	Less Critical
$0 < \bar{x} \leq 1{,}6$	Not Critical

RESULTS AND DISCUSSION

The results of the study revealed some findings about the level of students' mathematical critical thinking skills based on the geographical location of the school. The results of this study were processed using an interactive data analysis model.

Descriptive statistics of students' average critical thinking skills based on indicators in three schools with different geographical locations

Data was collected by administering tests to students from three different schools. The test data obtained from the students' critical thinking skills in mathematics learning are presented in the following table.

Table 5. Descriptive statistics of students' average mathematical thinking skills

IMCT	Geographical location of school			Max Score
	Highland (rural)	Border	Lowland (urban)	
	School A	School B	School C	
1	0,20	2,40	1,80	4,00
2	0,38	0,32	0,80	4,00
3	0,88	0,12	0,52	4,00
4	0	1,08	1,36	4,00
5	1,34	0,16	0,92	4,00
Average score	**0,56**	**0,82**	**1,08**	

Table 5 reveals the overall average critical thinking ability of students in the three different regions. School C in the urban area demonstrates the highest average critical thinking ability, followed by schools B and A. In another review, the border school obtained the highest average critical thinking ability in the first indicator, IMCT1 ($\bar{x}$=2.40), while the urban school acquired the highest average critical thinking ability for students in the second indicator, IMCT2, and fourth indicator, IMCT4 ($\bar{x}$=0.80; $\bar{x}$=1.36). It is important to note that these indicators were used to determine the critical thinking ability. The rural schools exhibited the highest average students' critical thinking skills in the third (IMCT3) and fifth (IMCT5) indicators ($\bar{x}$=0.88; $\bar{x}$=1.34). The results indicate that critical thinking skills of students vary geographically, with an average score lesser than two out of an ideal maximum of four. It can be concluded that the average level of critical thinking of the students in the three areas is low.

Level of Students' Critical Thinking Skills

The test results were used to determine the level of critical thinking ability among students based on their geographical locations. The classification of abilities was based on the specified score intervals. Based on the classification in Table 4, we can categorise the mathematical critical thinking skills of each student in the three different regions.

Table 6. Descriptive Statistics of The Gap in Mathematical Literacy Based on The Geographical Location of The School

Geographical location of school	Score	Classification of mathematical literacy
Highland	0,56	Not Critical
Border	0,82	Not Critical
Lowland	1,08	Not Critical

Table 6 shows that the average critical thinking ability of students in all regions is not critical. The ability of students in all three regions is of the same quality of not being critical in mathematics (in the interval $0<\bar{x}<1.6$). Next, we present the statistical analysis of students' critical thinking skills using the Kruskal-Wallis test.

Comparative Analysis of Critical Thinking in Mathematics

This comparative analysis uses the Kruskal-Wallis test because the data obtained are not normally distributed. The Kruskal-Wallis test is one of the non-parametric statistical tests that can be used to test whether there is a significant difference between groups of independent variables. The independent variable in this study is the geographical location of the school and the dependent variable is the students' ability to think critically about mathematics.

Hypothesis:

H0 : There is no difference in the mean rank of students' mathematical critical thinking ability between the three schools with different geographical locations.

H1 : There are at least two differences in the mean rank of the students' mathematical-critical thinking ability between the three schools with different geographical locations.

Basis for decision:

H0 is accepted : Sig value. > 0

H0 is rejected : Sig value ≤ 0

The results of the *Kruskal-Wallis* test are shown in the following table.

Table 7. Rank Inferential Statistics and Kruskal-Wallis Test

Rank		**Test Statistics**[a,b]	
Geographic Location of the School	Mean Rank	Test	Value
Lowland (urban)	59,42	*Chi-Square*	29,418
Borderland	43,78	*Df*	2
Highland (rural)	25,72	*Asymp. Sig.*	0,000

a. Kruskal Walls Test
b. Grouping Variable: Geographic Location of the School

Table 7 is the result of the Kruskal-Wallis statistical test to see whether or not there is a significant difference in students' mathematical critical thinking skills based on the geographical location of the school. The highest average rank is for students in lowland areas and the lowest average rank is for students in highland areas. The statistical test results show the value of Asymp. Sig. = 0.00 ≤ 0.5, which means that the H0 hypothesis is rejected. Thus, it can be concluded that there are at least two mean ranks of students' mathematical critical thinking skills that differ between the three schools. An overview of the mean rank of students' critical thinking skills in each region can be seen in Figure 8.

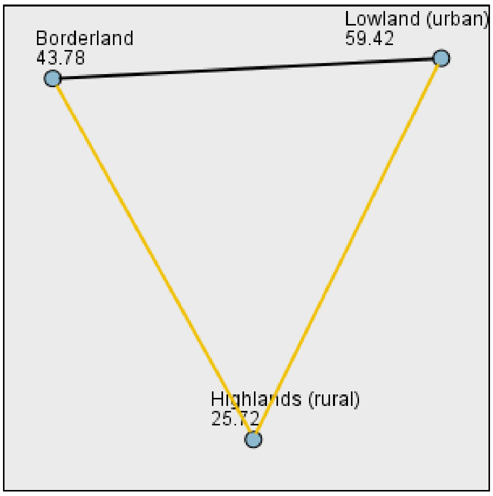


Figure 8: Average Rank of Critical Thinking Ability in Three Schools

Figure 8 shows the position of the three schools based on the average rank. The urban school has the highest average ($\bar{x}$=59.42), followed by the border school ($\bar{x}$=43.78) and the lowest is the rural school ($\bar{x}$=25.72). The location determines the difference in mean rank based on the slope of the line. The slope of the line between the border and urban schools is low (marked by the black coloured line), indicating that the average rank of the two schools is not very different. However, it can be seen that the slope of the line between border and rural schools, as well as between urban and rural schools, is both high (marked with a yellow coloured line), meaning that the average rank of the two schools is significantly different.

Next, we look at how students' critical thinking skills compare between schools with three different regional categories. In order to do this, we carried out a post hoc test, the results of which are shown in Table 8 with the hypothesis.

Hypothesis:

H_0 : The mean rank of students' mathematical critical thinking skills between the two schools is not significantly different.

H_1 : The mean rank of students' mathematical critical thinking skills between the two schools is significantly different.

Basis for decision making:

H_0 is accepted:Sig value. > 0

H_0 is rejected: Sig value ≤ 0

Table 9. Post-hoc Inferential Statistics for Mathematical Thinking Between Regions

Sample 1 – Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.
Highlands – Borderland	18.061	6.250	2.890	0.004	0,012
Highlands – Lowland	33.701	6.250	5.392	0.000	0,000
Borderland – Lowland	15.640	6.623	2.362	0.018	0,055

Table 9 presents a more detailed analysis of the average ranking across two schools in distinct regions. The academic performance of students in highland (rural) areas significantly varies from other regions, with an adj.Significance score of 0.012 compared to border schools and 0.000 against urban schools. Conversely, there is no significant difference in the academic performance of students in border areas compared to lowlands (urban) areas, with an adj. Significance score of 0.055. The variation in critical thinking abilities among schools is evident from the correlation depicted in Figure 8 and Table 9. The statistical test outcomes indicate a marked disparity in the average rank of critical thinking abilities of pupils from rural and urban/border regions, with the former showing significantly lower scores. However, the average rank of critical thinking abilities of students from urban and border regions is nearly equivalent

Research shows that students' average critical thinking skills are still low, especially in Majalengka City. The average score for junior high school students' mathematical critical thinking ability is below 1.2 with a maximum score of 4.0. This deficit in critical thinking ability is likely to affect the students' problem-solving abilities. When solving mathematical problems, it is important for students to think critically and rationally in order to use the information gained to find the right solution. Poor critical thinking skills can hinder the ability to solve mathematical problems. Students may struggle to ascertain the suitability of available data and subsequently have difficulty making informed decisions. Poor critical thinking skills in mathematics may also negatively impact their ability to reason in other domains such as literacy and science. Students may struggle to ascertain the suitability of available data and subsequently have difficulty making informed decisions. Failure to adopt a critical approach may result in a disinterest in validating the accuracy of acquired information, potentially leading to apathy and a lack of awareness concerning environmental issues.

Other findings provide more detail that there are significant differences in critical thinking skills between students in rural schools and students in urban and border schools. It is important to look at what might be influencing this difference. Based on the results of the interviews with teachers, there are differences that are quite influential in the development of students' mathematical critical thinking, including factors of student discipline, interest, teaching methods and use of learning facilities. Below are the results of interviews with several teachers at three different school sites on the factors of teaching methods and use of learning resources.

Researcher	:	*"How do you teach mathematics to your students?"*
Teacher A (rural)	:	*"I usually teach mathematics by the lecture method, using only the existing textbooks. Although there are teaching aids and facilities such as infocus and computers in the school, I rarely use them to teach mathematics to the students. "*

Teacher B (bordenland)	:	"*I sometimes have discussions with students during the learning process. Although there is still a lot of lecture activity in the classroom, I sometimes use teaching aids and use PowerPoint in the classroom.s"*
Teacher C (urban)	:	*"I often discuss with the students, use teaching aids, especially on the material of building space, and occasionally use different methods in teaching. I also sometimes use infokus to teach.".*
Researcher	:	*"Do you think that students are able to learn mathematics well??".*
Teacher A (rural)	:	*"Pupils in this school have little interest in mathematics. Sometimes they are deliberately late for maths lessons.".*
Teacher B (bordenland)	:	*"The students are quite disciplined in their learning. They are on time for class, but there are still few students who are interested in mathematics.".*
Teacher C (urban)	:	*"The discipline of the students still needs to be emphasised by the teacher, they still often need to be reminded of the "agreement" made at the beginning of the learning process.* *In terms of interest, of the 32 students I teach, only about 15 have a high interest in learning mathematics.".*

The results of the interviews with the teachers in the three schools show how different the treatment of teachers is when teaching mathematics. Teachers in rural areas rarely discuss and use different methods to construct students' knowledge. In contrast to the treatment given by teachers in the border and urban areas, they more or less try to create space for discussion with students, try to use new teaching methods and also use existing facilities such as props to create space for teaching and also infocus.

Qualitatively, the three regions exhibit similar levels of mathematical uncriticalness. Nevertheless, rural students demonstrated significantly lower mean rankings of mathematical critical thinking ability than their peers in border and urban regions. The mean rankings of critical thinking ability of students in border and urban regions were nearly equal. This finding is relevant to the interview results regarding teaching methods and students' interest in mathematics. Although each school will have students with different characteristics, representatives in each school from the three regions (highland, border and lowland) can show how teachers' teaching methods and students' interests can influence students' critical thinking skills. Other factors, such as family economy and parents' education, are also shown to influence the way students learn. Parents who have a good economy and education will provide many opportunities for their children to learn outside of school, such as private tutoring (Guo et al., 2020). Private tutoring has a positive impact on students' academic performance, while the net impact of private tutoring on students' academic performance is reduced in magnitude when it comes to parental education and economic status (Damayanthi, 2018). Private tutoring programmes are generally implemented in border and urban areas, and are much less common in comparison to rural areas. This factor has also been considered by researchers as a factor influencing students' mathematical skills, particularly in mathematical critical thinking.

The insufficient mathematical critical thinking abilities of Indonesian students stem from various factors, including the didactic transposition process used by teachers to instruct students. It remains unclear how educators can instil in students the propensity to question, examine, assess, and critique mathematical problems. Additionally, junior high school student's unfamiliarity with non-routine problems contributes to their low level of proficiency (Agus &

Purnama, 2022). In accordance with this, evidence indicates that mathematics education in Indonesia is primarily conducted in a mechanical manner and is often taught through the use of practical formulae, thereby lacking any constructive process for enhancing students' critical thinking abilities (Arisetyawan & Supriadi, 2020; Nurhasanah et al., 2017). Similarly, Majalengka Regency is a small district in Indonesia where, according to the researcher's findings, mathematics learning is typically unidirectional, with little class discussion between teachers and students, or among students themselves.

The deficient criticality levels of Indonesian students in mathematics has consequences on evaluation outcomes worldwide and nationally. Regarding the nationwide scope, the critical thinking skills of pupils in mathematics still show room for improvement (Farib et al., 2019). This is indicated by research spanning from 2017 to 2022 across elementary, junior high, and senior high school levels, which has found that the critical thinking skills of the average student in mathematics are still subpar (Anggraini et al., 2022; Benyamin et al., 2021; Danaryanti & Lestari, 2018; Dores et al., 2020; Irawan et al., 2017; Septiana et al., 2019). In an international context, the PISA assessment reveals that mathematics rankings among Indonesian students trail behind the average and fall short of international standards (Hewi & Shaleh, 2020).

The integration of critical thinking skills into mathematics education in Indonesia is currently lacking. In the initial measure of identifying the sufficiency of data to solve problems, students living in border areas display greater proficiency than their counterparts. Conversely, students residing in urban areas exhibit better skills in the indicators of recognizing the underlying concepts of problem-solving and verifying the validity of statements. These outcomes imply that students' proficiency in mathematical critical thinking does not uniformly align with all indicators. Students in rural areas exhibit superior analogy and generalization inference abilities compared to their counterparts in other regions. This finding defies the assumption presented by (Suparmini & Wijayanti, 2015) that urban communities are more rational than rural ones. On the contrary, our study indicates that rural communities possess better rationality in mathematics to deduce logical conclusions and generalizations. Therefore, variations in the innate traits of individuals from diverse geographical regions do not bear significance on the markers for mathematical critical thinking abilities of students.

There are additional factors to consider, including access to facilities and information. Urban and border students generally have better facilities and easier access to information. The Indonesian government allocated funds towards ensuring equal learning opportunities in schools across all regions. To address disparities in access and quality, the Ministry of Education and Culture implemented a zoning system for new student admissions (Kemendikbud, 2018). However, generally, parents in urban areas and border regions expend significant resources on private schools, private tutoring and materials to secure top grades for their children. Undoubtedly, children who have more educated and affluent parents and those living in urban areas have an advantage (Gumus & Atalmış, 2012). The availability of additional facilities and the ease of access significantly impact students' mathematical achievement and critical thinking skills.

Students in all regions, particularly Majalengka, Indonesia, demonstrate a low level of mathematical critical thinking ability. The analysis by indicator reveals variation in students' mathematical critical thinking skills across indicators. However, it is important to note that being described as 'uncritical' does not necessarily mean that students lack all of the characteristics of critical thinking ability. Hence, the evaluation that students lack criticality is a generalisation of the mean score of all parameters. Additionally, the findings of this research indicate that the zoning policy executed by the Indonesian government has not adequately facilitated the enhancement of students' mathematical aptitude. Inequalities persist in access to and quality of education between urban and rural students. The results demonstrate noteworthy disparities in mathematical critical thinking skills amongst students across the three diverse regions.

The findings of this study contribute to the attention of researchers and teachers to find effective ways to overcome the low critical thinking skills of students, especially in the field of mathematics. Among the learning methods that are widely used to improve mathematical critical thinking skills are problem-based learning and STEM. In addition, digital-based learning is needed to facilitate students' critical thinking skills (Suryawan et al., 2023). Digitalisation of learning can be in the form of developing problem-based digital modules that facilitate students' cognitive conflicts, and the use of various learning technologies that can stimulate students' thinking.

Implication

The findings demonstrate persistent disparities in students' maths competency across three distinct regions - urban, border, and rural. While the average level of critical thinking ability in maths is of low quality across all three areas, there is no significant variation. It is evident that students' critical analysis skills in maths require improvement across all regions. The findings of this research have implications for various stakeholders, including mathematics educators, caregivers and policymakers within the Indonesian educational context. Educators should increase their focus towards enhancing students' critical thinking abilities within mathematics teaching using innovative approaches and learning aids. It is recommended that teachers familiarise learners with analytical problems to improve their critical thinking skills. Based on the findings of this study, it is recommended that parents of students, particularly those residing in rural areas, should pay closer attention to their children's education and provide suitable education facilities suited to their individual abilities despite the challenges. In addition, government policies play a significant role in the disparities in mathematics proficiency across these three regions. This issue is a cause for concern among education policymakers, who must develop more effective policies to ensure that students throughout Indonesia have equal access to educational facilities and resources.

Limitation and Suggestion for Futher Research

This study solely focuses on regional characteristics of research schools in three different regions: Highland (rural), Border, and Lowland. We have excluded subjective evaluations, utilized technical terminology when necessary, and maintained grammatical correctness throughout the text. Our aim is to compare these three regions and examine the development of critical thinking skills in mathematical education across them. This approach allows us to gain insight into how teachers and students collaborate to improve mathematical critical thinking skills. For educators, it is evident that practising problem solving and encouraging critical thinking amongst students is essential. The findings demonstrate that mathematical critical thinking skills in Majalengka's three regions remain inadequate. However, a closer analysis highlights discrepancies among the levels of critical thinking within the regions, exemplified in Table 9. It should be noted that this study's scope is confined to one city and is not extensive. We recommend that researchers interested in studying the same topic broaden the scope of their investigations to include comparisons within the country and beyond. Our study primarily examined cube and cuboid materials, but we also propose exploring other relevant materials.

CONCLUSIONS

The study has demonstrated that, on average, students exhibit a lack of critical thinking skills in mathematics, as evidenced by their test scores is below 1.2 with a maximum score of 4.0. However, statistical analysis revealed a significant difference in critical thinking abilities among students in urban, border, and rural areas (urban score = 59,42, borderland score = 43,78, rural score = 25,72). Urban students have a higher overall critical thinking ranking than their counterparts in rural and border areas. Additionally, the critical thinking ranking of border area students is nearly equivalent to that of urban students. This statement addresses the factors influencing students' mathematical critical thinking abilities, prevalent in Indonesian society. Inequalities in access, teachers' teaching methods, pupils' interests and parents' education and economic circumstances contribute to this phenomenon. The main reason for the difference in students' critical thinking skills between geographically different schools is the students' learning habits, which are influenced by teachers, interests and parental conditions.

AUTHOR CONTRIBUTIONS STATEMENT

IN was involved in the conceptualization, design, analysis, securing funding, and writing of the project. NP contributed to the conceptualization, provided material support, and gave the final approval. JAD was responsible for the analysis method, editing, and supervision of the project. SM served as the interpreter and contributed to the analysis method.

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