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Behind the Numbers: Revealing the Logical-Mathematical Thinking Abilities of Border College Students

Nessy Pattimukay

Faculty Of Teacher Training And Education, Pattimura University
Jalan Ir M Putuhena, Ambon, Maluku, Indonesia
n355y_p@yahoo.com

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Abstrak

Pengembangan daerah perbatasan tidak hanya ditentukan dari sumber daya alam, tetapi juga kualitas sumber daya manusianya. Kemampuan berpikir logis matematis merupakan salah satu kompetensi yang dibutuhkan dalam berbagai bidang pekerjaan. Oleh karena itu, kemampuan tersebut perlu dimiliki agar tercipta kualitas sumber daya manusia yang dapat bersaing di era global. Tujuan penelitin ini adalah untuk memberikan gambaran yang jelas tentang sejauh mana kemampuan berpikir logis matematis mahasiswa yang berada di perbatasan, agar dapat mengetahui potensi yang dimiliki serta hal-hal yang perlu ditingkatkan khususnya dalam pembelajaran matematika. Penelitian ini merupakan penelitian kuantitatif deskriptif dengan desain penelitian Cross-Sectional. Populasi dalam penelitian ini adalah seluruh mahasiswa Pendidikan Guru Sekolah Dasar pada Universitas Pattimura. Pengambilan sampel dilakukan dengan teknik purposive sampling, artinya sampel dipilih secara selektif berdasarkan kriteria yang telah ditentukan. Penelitian ini melibatkan 25 mahasiswa pendidikan guru sekolah dasar yang menempuh mata kuliah pendidikan matematika dan berdomisili di wilayah perbatasan sebagai sampel penelitian. Pengumpulan data dilakukan melalui tes kemampuan berpikir logis matematis. Dalam penelitian ini, data yang terkumpul diolah dan dianalisis menggunakan metode deskriptif. Hasil penelitian menunjukkan bahwa rata-rata kemampuan berpikir logis mahasiswa di daerah perbatasan adalah 35, 17. Secara umum, tingkat kemampuan berpikir logis matematis mahasiswa di wilayah perbatasan tergolong rendah. Indicator penarikan kesimpulan logis berada pada kategori sedang. Sedangkan indicator pengidentifikasian informasi yang termuat dalam soal serta menyelesaikan masalah matematis secara rasional berada dalam kategori sangat rendah. Kemampuan berpikir logis mahasiswa calon guru sekolah dasar yang rendah akan berdampak pada terhambatnya pembangunan daerah yang membutuhkan kualitas sumber daya manusia. Selain itu juga berdampak pada pendidikan di sekolah dasar karena siswa akan kesulitan memahami materi jika diajarkan oleh guru yang kurang menguasai konsep yang diajarkan. Dengan demikian, penelitian lanjutan diperlukan untuk meningkatkan serta mengembangkan kemampuan berpikir logis matematis.
Kata Kunci: Kemampuan Berpikir Logis; Peluang; Nilai Kebenaran; Pendidikan Matematika

Abstract

The development of border areas is not only determined by natural resources but also by the quality of human resources. The ability to think logically and mathematically is one of the competencies needed in various fields of work. Therefore, this ability needs to be possessed to create quality human resources that can compete in the global era. This study aims to provide a clear picture of the extent of the ability to think logically and mathematically of students in the border area, to know the potential they have and things that need to be improved, especially in mathematics learning. This study is a descriptive quantitative study with a Cross-Sectional research design. The population in this study

were all Elementary School Teacher Education students at Pattimura University. The sample selection used a purposive sampling technique because the sampling was carried out with certain considerations. The sample in this study was elementary school teacher education students who offered mathematics education courses totaling 25 people who were in the border area. Data collection was carried out through a mathematical logical thinking ability test. The data analysis technique used descriptive analysis. The results of the study showed that the average logical thinking ability of students in the border area was 35.17. Overall, the mathematical logical thinking ability of students in the border area was in a low category. The indicator of logical conclusion drawing is in the moderate category. The indicator of identifying information contained in the problem and solving mathematical problems rationally is in the very low category. The low logical thinking ability of prospective elementary school teachers will have an impact on hampering regional development that requires quality human resources. In addition, it also has an impact on education in elementary schools because students will have difficulty understanding the material if taught by teachers who do not master the concepts being taught. Therefore, further research is needed to improve and develop logical-mathematical thinking skills.

Keywords: Mathematical Logical Thinking Ability; Mathematics Education; Probability; Truth Value

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I. INTRODUCTION

Mathematics is a science that uses deductive reasoning and believes in the truth of an argument based on logic. (Arsyad & Ahmar, 2017; Yunisca & Nasution, 2023). Piaget defined logical thinking as the ability to observe in abstract and concrete operational steps. Students at the concrete operational stage can use logical thinking skills to solve certain problems (Bozdogan, 2007; Tajuddin et al., 2023). Students' capacity to reason is one of the most crucial aspects of learning mathematics.

In BSNP and NCTM (Rohaeti et al., 2014:54), the vision of mathematics is to develop mathematics learning through logical, systematic, critical, careful, and creative thinking skills. Michael S. Stevens (Rayin, 2016) emphasized that a person's ability to sort, make comparisons, evaluate, and determine choices and solve problems is included in the ability to think logically. This can be assessed using indicators of logical thinking achievement. Logical thinking ability, as expressed by Tobin and Cappie (1981) and quoted in Nurismawati et al. (2018), is assessed using the TOLT test, which measures five aspects: the ability to manage variables, make proportional, probabilistic, correlational, and combinatorial conclusions. According to Demirel (Bakir & Oztekin-Bicer, 2015), logical thinking includes using practical thinking in calculations, making scientific problem solving, being able to differentiate concepts, classify, generalize concepts, calculate, and make assumptions. previously known knowledge. Sari et al. (2018: 13) define logical thinking as the capacity to get at the truth by rules, patterns, or logic. In addition, Diana (2018) argues that making conclusions and solving problems is a logical thinking activity. Piaget (1983) stated that cognitive development can be divided into four different stages: sensory-motor, preoperational, concrete, and formal. During the formal stage, individuals can engage in reasoning using abstract images and expressions. This stage is characterized by intellectual maturity, which allows students to solve problems effectively through systematic experimentation. During the specialized activity phase, students can use logical thinking skills to solve specific problems

According to Sumarmo (2012: 19), indicators of logical thinking ability include: (1) students' ability to generalize, (2) students' ability to make predictions based on opportunities, (3) students' ability to understand correlations between variables, (4) students' ability to combine variables, (5) students' ability to make analogies, (6) students' ability to prove, and (7) students' ability to analyze and synthesize. According to Ni'matus (Noviani, et al., 2020:16), indicators of mathematical logical thinking ability include: 1) structured thought flow, 2) ability to convey arguments, and 3) ability to conclude. In this study, based on various opinions, indicators of logical thinking ability are the ability to identify information in problems, make logical connections between facts and concepts, solve mathematical problems rationally, and draw conclusions.

As stated by Muhadjir, Minister of Education and Culture (Antaranews 2017),

the Aru Islands Regency is one of the underdeveloped and remote regencies in Maluku. Aru Islands Regency is one of eight regencies in Maluku Province which is located in the southeastern part of Maluku Province and is directly adjacent to neighboring Australia in the Arafura Sea. Pattimura University's Study Programme Outside the Main Campus (PSDKU) in the Aru Islands Regency is a breakthrough and strategic service to expand access to education and the quality of higher education for the nation's children in the Aru Islands and surrounding areas with the geographic characteristics of the islands with the status of the Outermost, Underdeveloped and Disadvantaged (3T).

Students in border areas are often faced with various challenges that can affect their learning activities and thinking skills (Zakso et al., 2021). Limited access and inadequate educational facilities can hinder the learning process. In addition, different educational backgrounds at elementary and secondary school levels are important factors that can affect students' readiness when studying various sciences, especially mathematics, in college. This is reinforced by the results of research by Ratumanan and Laurens (2016), regarding the mastery of direct and indirect objects of mathematics in high school graduates in 11 districts in Maluku Province. Aru Islands Regency is one of the districts used as a sample in the study. The results of the study show that the level of understanding of direct and indirect mathematical concepts of high school graduates in the Aru Islands Regency is very low. Education is a factor that greatly influences the quality of human resources and also determines regional progress. According to the research findings obtained (Purba, 2023), the average value of the mathematical concept understanding ability of PSDKU Pattimura University students in the Aru Islands was 48.5 which is in the low category.

Primary School Teacher Education is one of the Study Programmes available at PSDKU Aru Islands Regency. Many children from the Aru Islands Regency are registered as PGSD PSDKU students in the Aru Islands Regency. One of the courses that need to be mastered by prospective elementary school teacher students is mathematics education. Mathematics education courses contain basic mathematics materials and their learning in elementary schools. To answer problems about daily life and make the best judgments when presented with multiple options, students must possess mathematical logical thinking abilities. In addition, Elementary School Teacher Education students are prospective teachers who are the founders of science, especially mathematics and need to be equipped with logical thinking skills to instill a correct understanding of the basic concepts of mathematics in students. In addition, one of the basic skills that students must have is the ability to think logically, which allows them to draw correct conclusions and solve everyday problems. The ability to think systematically and structure is more than just remembering facts; it includes a deep understanding of problems and the ability to analyze and combine information and solve problems rationally.

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Previous research on logical thinking skills has focused more on students in urban areas (Septiani, 2018; Sari, 2020; Ilmadi, et al., 2022; Pamungkas et al., 2022). Research related to logical-mathematical thinking in elementary school teacher education students in border areas is still very limited or even non-existent. Therefore, this study is important to provide a clear picture of the extent of the logical-mathematical thinking skills of students in border areas, to know the potential they have and things that need to be improved, especially in mathematics learning. In addition, the findings of this study can be used as a basis for consideration in evaluating programs to improve the quality of education. The findings of this study can provide input for policymakers in formulating better education policies for border areas.

II. METHOD

This study uses a descriptive quantitative approach with a Cross-Sectional design, which aims to describe the level of logical thinking skills of students in border areas. All students registered in the Elementary School Teacher Education study program at Pattimura University are the population in this study. The sample in this study was selected using the Purposive sampling method. In this study, sample selection was carried out intentionally (purposive sampling) by setting specific criteria that were relevant to the research objectives. The sample in this study amounted to 25 people. The research sample was Elementary School Teacher Education students for the 2022/2023 academic year who were in border areas that offered mathematics education courses. This research was conducted at the PSDKU campus of Aru Islands Regency. The data collection technique was carried out through a mathematical logical thinking ability test. The instrument used in data collection is a logical thinking ability test instrument. The measuring instrument used in this study was a written test consisting of 4 descriptive questions. The questions in the test are designed based on logical thinking indicators. The test results are used to get an overview of the logical thinking skills of students who live in border areas. The test instrument was tested for validity and reliability before use. The data obtained from the test were then analyzed using data analysis techniques consisting of data reduction, data presentation, descriptive statistical calculations, and conclusion. The scores obtained from the test results were then converted to scores with a range of 0 - 100, using the formula:

$$\text{Score} = \frac{core\ obtained}{total\ score} \times 100$$

The data from the test results of students' mathematical logical thinking skills are grouped based on the following categories.

Table 1.
Logical Thinking Ability Categories

Nilai	Kategori
$0 \leq X < 20$	Very low
$20 \leq X < 40$	Low
$40 \leq X < 60$	Medium
$60 \leq X < 80$	High
$80 \leq X \leq 100$	Very high

(Modified Arikunto, 2014)

In compiling test instruments to measure the logical-mathematical thinking abilities of borderline students, the following indicators of logical thinking abilities are used as references.

Table 2.
Logical Thinking Ability Indicators

No	Indicators	Achievement
1.	Understand and identify the information contained in the problem	1.1 Students can explain the meaning of the questions given in their own words. 1.2 Students are able to convey/write down all information about what is known and what is asked in the question.
2.	Establish logical connections between ideas and real evidence.	2.1 Students can make plans to solve the problems given. 2.2 Students can explain each step used in solving the given problem.
3.	Solving mathematical problems rationally	3.1 Students can solve the problems given appropriately according to the steps that have been made to solve the problem 3.2 Students believe in the truth about the steps used to solve problems.
4.	Drawing logical conclusions	Students are able to make clear conclusions/interpretations based on the results of their solutions.

III. RESULT AND DISCUSSION

The logical thinking ability test was given to students in border areas totaling 25 students. The following data is a converted logical thinking ability test score with a range of 0 - 100.

Table 3.
Data presentation on the level of students' logical thinking ability based on each indicator

No	Logical Thingking Ablity Indicator	Avarage	Highest Score	Lowest Score	Category
1	Understand and identify the information in the problem	17, 82	50	0	Very Low
2	Make logical connections between concepts and facts	87,5	100	0	Very high
3	Solve Mathematical problems rationally	20, 83	50	0	Low
4	Draw logical conclusions	47,67	79,41	0	Medium

Based on Table 4, it is obtained that the highest frequency of values is in the range of 0-20 in the very low category. Data on the Logical Thinking Ability Test Scores of Students in border areas are then statistically processed in Table 4.

Table 5.
Statistical Description of Student's Logical Thinking Ability Test Scores

Descriptive Statistic	Score
Average	35, 17
Standard Deviation	21, 98
Maximum Value	64,29
Minimum Value	2,38
Mode	54,76

Based on Table 5, it is obtained that the average student score on the logical thinking ability test is 35.17. This shows that the average logical thinking ability is in the low category. The standard deviation value of 21.98 shows that the logical thinking ability of students in border areas has quite a large variation. These results

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indicate that students' logical thinking abilities vary greatly.

The following describes student answers per indicator:

A. Understand and identify the information in the problem

In this indicator, the average score obtained was 17.82. This result shows that the ability of students to understand and identify information in the problem is in a very low category. In this problem, students were asked to determine the probability of marbles being taken based on color. In their answers, many students did not include the information given in the question and did not write the question asked in the question. In addition, students worked on the problem not coherently but immediately wrote the answer, and the answers written were wrong. This means that overall, students do not understand the problems given.

This is supported by research by Hakim & Devianti (2021), which found that students were not yet able to recognize and identify the information contained in the questions.

The following is a snippet of student answers:

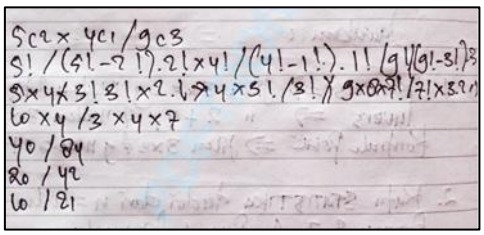

Figure 1. Student answer

B. Make logical connections between concepts and facts

In this indicator, the average score obtained is 87.5. This result shows that students' ability to make logical connections between concepts and facts is in a very high category. In this question, students were asked to determine the converse, inverse, and contraposition of the given implication statement. Most students answered this question correctly. Based on Figures 2 and 3, students can understand well about the implications and how to determine the converse, inverse, and contraposition using symbols/formulas. Based on these symbols or formulas, students can make converses, inverses, and contrapositions correctly. This means that students understand the relationship between implication, converse, inverse, and contrapositive to make plans and understand the steps to solve the problem.

Here is a snapshot of the student's answers:

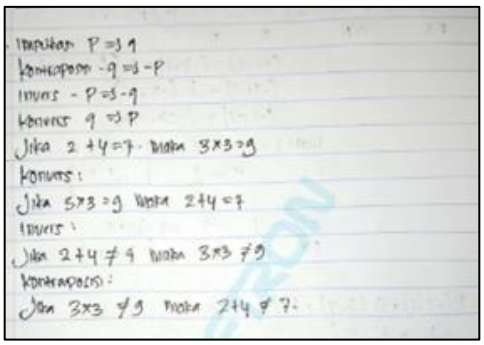

Figure 2. Student answer

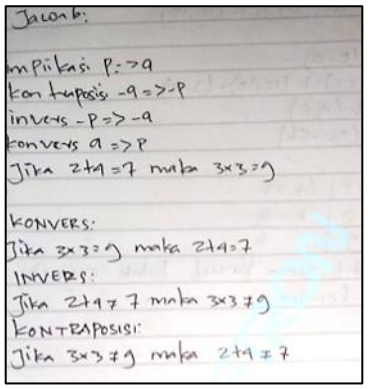

Figure 3. Student answer

C. Solve mathematical problems rationally

In this indicator, the average score obtained was 20.83. This result shows that the ability to solve mathematical problems rationally is in the low category. In this problem, students are asked to determine the value of x that fulfills the implication and bi-implication statements so that they are true. Based on students' answers, it is found that most students do not first make or write down the truth value of an implication or bi-implication. This needs to be done to determine the value of x that fulfills such that the implication or by implication statement is true. In addition, students were also mistaken in performing the addition operation on the linear equation, resulting in incorrect calculation results. Students also misunderstood the concept of prime numbers. Their mistake can be seen in their work which states that 4 is a prime number.

This means that students have not been able to compile the right steps to solve this problem and do not have a correct understanding of the mathematical concepts given. Therefore, students cannot solve mathematical problems rationally.

Here is a snippet of student answers:

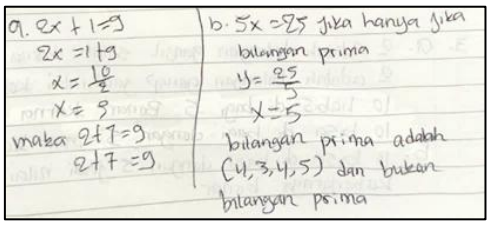

Figure 4. Student answer

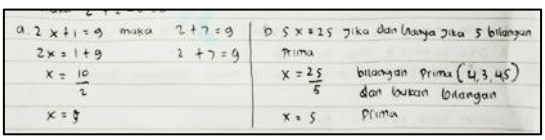

Figure 5. Student answer

pendukung dapat berupa gambar (foto/grafik/bagan) atau tabel. Gambar/tabel tersebut harus diberi nomor urut dan keterangan ringkas dengan format; centered, TNR 10, spasi 1. Isi tabel ditulis dengan format TNR 10, spasi 1. Garis gambar dihilangkan. Keterangan gambar/tabel tidak diperkenankan serupa antara satu sama lain.

D. Draw logical conclusions

In this indicator, the average score is 47.67. This result shows that the ability of students to make logical conclusions is in the moderate category. This indicator is found in question number 3, in this question, students are asked to analyze using the distance formula whether the known points are collinear or not. From the analysis of students' answers, it was found that some of them were able to record all the information given in the questions. However, some students do not write down the information contained in the problem. In addition, most students answered incompletely. Students only calculate the distance between points P and Q, Q and R, and P and R, without concluding these calculations. Students did not make the relationship between the distance of points P and R and the total distance PQ + QR = PR, which means that if the given points are collinear, then the distance of points P and R will be equal to the total distance of PQ and QR. This means that students have not been able to make conclusions/estimates and interpretations based on the information contained in the problem.

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This is similar to the results of research conducted by Sari (2020), that there are students who have difficulty in making conclusions or estimates based on the correlation between two variables. In line with the results of research by Ilmadi, et al. (2022), students have difficulty in providing logical conclusions.

The following is a snippet of student answers:

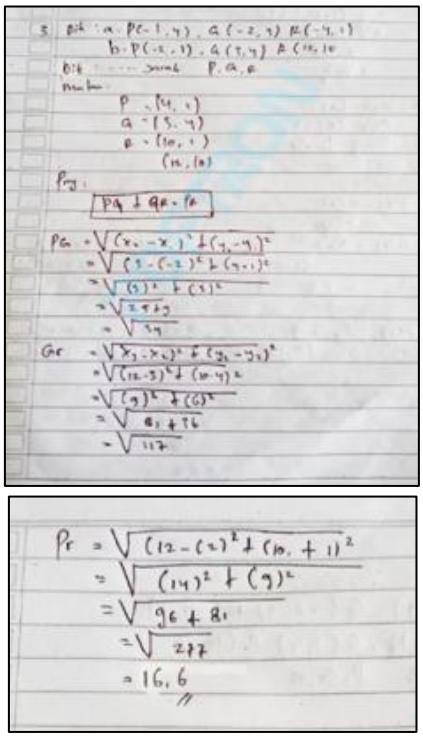

Figure 6. Student answer

Based on the results of the above explanation, shows that students in border areas have difficulty in solving mathematical logical thinking skills related to identifying information contained in the problem and solving mathematical problems rationally. The indicator of solving mathematical problems rationally is closely related to the previous indicator. To be able to solve mathematical problems rationally, it is necessary to have a correct understanding related to the problem or problem given. This understanding can be in the form of identifying what information is known in the problem or problem. In addition, identifying what is asked in the problem. Then to solve the given problem or problem, it is necessary to develop a solution plan by making connections between one concept and another, or the relationship between facts and different concepts. Based on the student's answers, it was found that there were still many students who could not identify the known information in the problem correctly. This can make it difficult for students to make logical connections between concepts and facts. This has an impact on students' lack of understanding and difficulty in solving mathematical problems rationally. The results of this study show that the lack of understanding and difficulties experienced by students in border areas which have an impact on low logical thinking skills are influenced by the lack of teaching staff and learning facilities and infrastructure which are still very limited or even non-existent. This is reinforced by the results of Victory's research (2022) which states that the comparison of the number of teachers is not comparable to the number of students, and the provision of learning facilities and infrastructure is inadequate. Therefore, the development of the education sector in border areas needs serious attention from various groups, especially the government. Further action is to overcome the difficulties experienced by students to improve students logical mathematical thinking skills. This is needed to improve the quality of education.

IV. CONCLUSION

The results of this study conclude that the logical thinking ability of students in border areas is low. The average logical thinking ability of students in border areas is 35, 17. The lowest aspect of students' logical-mathematical thinking ability is seen in their ability to identify information and questions in problems. In addition, student difficulties are related to indicators of solving mathematical problems rationally.

Referring to the conclusion, the recommendations that need to be given regarding logical-mathematical thinking skills are: the importance of efforts to overcome the challenges faced by students in the border, remote, and outermost areas in developing logical-mathematical thinking skills, for the sake of improving the quality of education and the progress of the nation; there needs to be the development of more effective learning models both in elementary, and secondary schools and in universities to improve the ability to think logically mathematically both in border, underdeveloped, and remote areas; It is necessary to design a training program for teachers and lecturers that focuses on developing students' logical and mathematical thinking skills; and a mathematics curriculum that is relevant to the needs of students and university students in border areas needs to be developed.

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AUTHOR'S BIOGRAPHY

Dr. Nessy Pattimukay, S.Pd., M.Pd.

Born in Waai Village, Central Maluku Regency, Maluku Province on October 21, 1983. She completed her undergraduate education at Pattimura University, Mathematics Education Study Program in 2006. She earned her master's degree in 2009 at the Mathematics Education Study Program, Universitas Negeri Surabaya. In 2019, she completed her doctoral education at the Mathematics Education Study Program at Universitas Negeri Surabaya.