International Journal of Education and Humanities (IJEH), 6(3) 2026:511-5228
http://i-jeh.com/index.php/ijeh/index
E-ISSN: 2798-5768

How Does the Algebraic Thinking Process of Students Solve Numeracy Problems Based on Brain Dominance?

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Abstract

The low algebraic and numeracy abilities of students indicate the importance of understanding the thought processes underlying mathematical problem solving. Therefore, studying algebraic thinking processes based on brain dominance is important as a basis for developing more effective learning strategies. This study aims to analyze the algebraic thinking process in solving numeracy problems based on brain dominance. This study uses a qualitative method with an exploratory approach. The data collection technique is an exploratory process using the method think out loud and unstructured interviews. The instruments used were the researcher as the key instrument, numeracy questions and brain dominance tests. Data sources were divided into 3 categories, including the implementation location, namely the school, the actors in this study were taken using an exploration process, namely 2 subjects, and the activity in this study was the algebraic thinking process of students in solving numeracy problems. Data analysis was carried out with the following steps: data reduction, data presentation, and drawing conclusions. The results of the study were that students with left and right brain dominance both fulfilled the algebraic thinking indicators (Pattern Seeking, Pattern Recognition, and Generalization) which were in line with the numeracy indicators (Knowing, Applying, and Reasoning), although there were differences in the thinking process. Left brain dominant students tended to think more systematically and consistently in identifying information, building mathematical models, and drawing conclusions, while right brain dominant students relied more on visual understanding, intuition, and exploration of various alternative solutions.

Keywords: *Algebraic Thingking Process, Numeracy, Brain Dominance*

A. Introduction

Students have different thought processes, resulting in what they think and how each student thinks is also different (Sukmaangara & Madawistama, 2023). Different thinking processes allow teachers to make certain judgments about what is thought and how thoughts are produced. Thinking processes can assess someone about what and how thoughts are produced (Shadrikov et al., 2016). Different thinking processes enable teachers to make specific assessments of what and how students think, allowing them to understand how students think when solving problems. Students' thinking processes can help teachers plan the learning process, ensuring that their instruction maximizes students' potential.

One of the thought processes that can be maximally developed is algebraic thinking. One of the main challenges in developing algebraic thinking is the transition from arithmetic to algebraic thinking. Wahyuni et al., (2023) highlighted that students often interpret letters in algebra simply as substitutes for specific numbers, without understanding their broader meaning

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as representations of generalized numbers. This suggests the need for a teaching approach that emphasizes a deeper understanding of algebraic concepts.

According to data, Indonesian students show alarming results in algebra. According to the 2015 TIMSS study, the average score for Indonesian students in mathematics was only 397, far below the international average of 500 (TIMSS, 2015). This fact places Indonesia in a much lower ranking, 44th out of 49 countries. The Trends in International Mathematics and Science Study (TIMSS) assessment provides an overview of student achievement in mathematics and science. The assessment covers all areas of mathematics, including algebra as one of the core areas. Algebra is a core topic in mathematics, especially at the secondary school level, with a vital role in supporting achievement in various other branches of mathematics such as analytical geometry, calculus, and statistics (Sibgatullin et al., 2022). This assessment ranking indicates a fundamental problem in algebra learning in Indonesia that requires special attention. This is a challenge that must be addressed.

Students' difficulties in algebra are often caused by a lack of conceptual understanding and symbolization skills. These difficulties are often caused by their failure to grasp algebraic concepts and algebraic notation in solving algebra problems, resulting in students having a low level of algebraic knowledge (Akgun & Ozdemir, 2006;Feurzeig, 1986;Hoon et al., 2020). Students' difficulties in learning algebra are dominant because 60% of algebra problems at each level in the mathematics curriculum require a high cognitive level, as well as 32% of misconceptions of algebraic symbols and difficulties in mathematizing algebra (Jupri et al., 2014;Ubuz et al., 2010). Many students only understand algebraic symbols as substitutes for numbers without realizing that these symbols represent broader relationships and generalizations. As a first step to addressing this challenge, research into students' algebraic thinking processes is essential. By understanding how students process and apply algebraic concepts, educators can develop more effective learning strategies. This suggests that the first step must be understanding students' algebraic thinking processes so that we can understand how students apply mathematical concepts, especially algebra.

Numeracy, which is closely related to the concept of algebra, is an important skill in mathematics learning that supports students to reason, understand, and solve problems in various contexts.Regulation of the Minister of Education, Culture, Research, and Technology of the Republic of Indonesia Number 5 of 2022 concerning Graduate Competency Standards in Early Childhood Education, Elementary Education, and Secondary Education (2022) wrote that one of the main competencies assessed in the Graduate Competency Standards (SKL) is numeracy, namely the ability to think logically using mathematical concepts, procedures, facts, and tools to solve problems related to oneself and the surrounding environment. This shows that numeracy, along with algebra as one of its branches, plays a crucial role in developing students' critical and logical thinking skills to face real-world challenges.

The Programme for International Student Assessment (PISA), initiated by the Organization for Economic Co-operation and Development (OECD), routinely evaluates the numeracy skills of students in various countries. The evaluation results indicate that numeracy skills need to be improved in education (OECD, 2023). This research shows that numeracy mastery is an important indicator in measuring students' readiness to face the demands of the 21st century. Furthermore,Tout & Gal (2015) examines that numeracy literacy not only functions to improve students' mathematical skills, but is also a step forward in preparing the younger generation to adapt to continually developing changes.

The global commitment to improving numeracy skills is reflected in the Sustainable Development Goals (SDGs) agenda initiated by the United Nations (UN). One of the 17 SDGs is to ensure inclusive and equitable quality education, with education being a key driver of most other development goals. The United Nations Department of Economic and Social Affairs (UN DESA) states that without concrete steps, an estimated 300 million students will lack basic literacy and numeracy skills by 2030 (United Nations, 2023). To address this, one of the targets of the Sustainable Development Goals (SDGs) is that by 2030, all adolescents and most adults, both men and women, will achieve adequate levels of literacy and numeracy skills. This is measured by the proportion of the population in a given age group that has achieved at least a functional level of proficiency in (a) reading and (b) numeracy, taking into account gender differences. This research is expected to contribute to the achievement of the Sustainable Development Goals (SDGs), particularly in improving the quality of education and numeracy skills of students, as well as preparing them for active participation in society in the future.

Ozdogru (2014) illustrates the relationship between the brain, education, and psychology which can be seen in the following image:

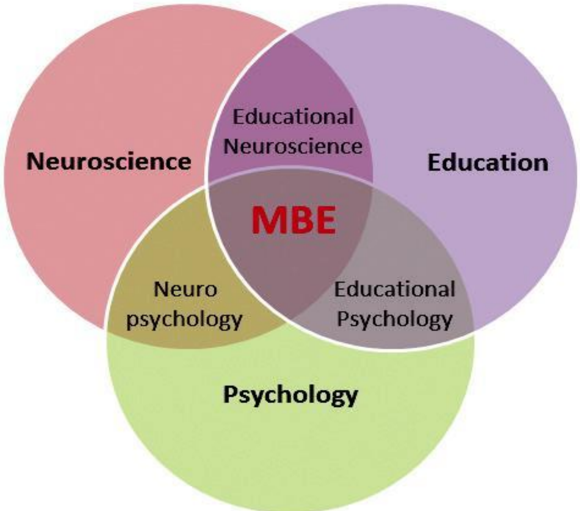


Figure 1. *Transdisciplinary Field of Mind, Brain, and Education*(MBE)(Ozdogru, 2014)

Mind, Brain, and Education (MBE) is a scientific study that examines neuroscience, psychology, and education, contributing to a better understanding of how humans learn. Based on Figure 1, MBE explains that there is a relationship between these three fields: neuroscience, psychology, and education. Mind, Brain, and Education (MBE) examines these three fields in detail, including the study of neuroscience and education (Educational Neuroscience), neuroscience and psychology (NeuroPsychology), and education and psychology (Educational Psychology) or the study of the three. The thinking process is part of the study of educational science, while brain dominance is part of the study of neuroscience in the form of the brain.

The relationship between the three explains that there are other internal factors that influence learning, namely the brain's working system. Jensen (2008) He proposed the relationship between learning and the brain, stating that there are seven factors that influence learning, one of which is the brain. The connection between the brain and learning leads to a relationship between the brain and the ability studied, namely algebraic thinking. Research on the brain in learning still requires further development. Interest in and developments in neuroscience, particularly the brain, have sparked the need for further research (Ozdogru, 2014). Researchers need to conduct research to develop the brain's connection to the learning process. The need for further research in neuroscience and the connection between the brain and learning have led researchers to be interested in researching brain dominance.

The human brain is divided into two parts: the left and right hemispheres. Humans use the left and right hemispheres alternately and collaboratively. Both hemispheres play an equally important role in the learning process, but each person has a tendency or dominance in the use of each hemisphere. Sometimes people are left-brain dominant, sometimes they are balanced, or sometimes they are right-brain dominant. The use of brain tendencies can influence learning because brain dominance is a crucial factor in a person's performance (Jensen, 2008). The results of the research conductedKordjazi & Ghonsooly (2015) also found that brain dominance is an important factor in a person's performance.

Previous research has shown various challenges in the algebraic thinking process, solving numeracy problems, and the influence of brain dominance on students' ability to solve mathematical problems. Cahyanintyas et al. (2018) and Kusuma A. et al., (2024) revealed that students' difficulties in representing algebraic information and the differences in strategies between students with high and low abilities require strengthening concrete and abstract representation skills. In the context of numeracy, Nurmalitasari & Khoiri (2024) identify fragmentation of understanding of statistical concepts that require a process-based thinking approach, while Cahyati & Siswono (2022) This study highlights the influence of adversity quotient (AQ) on students' numeracy skills, emphasizing the importance of real-world context-based learning. Sukmaangara et al. (2021) and Sukmaangara & Madawistama (2023) showed differences in mathematical problem-solving strategies based on brain dominance, but this influence has not been linked in depth to algebraic and numeracy thinking processes. The gap found is the lack of research that integrates these three aspects, so this study aims to fill this gap by analyzing the interaction between algebraic thinking processes, numeracy problem solving, and brain dominance to produce a more effective approach to mathematics learning.

B. Methods

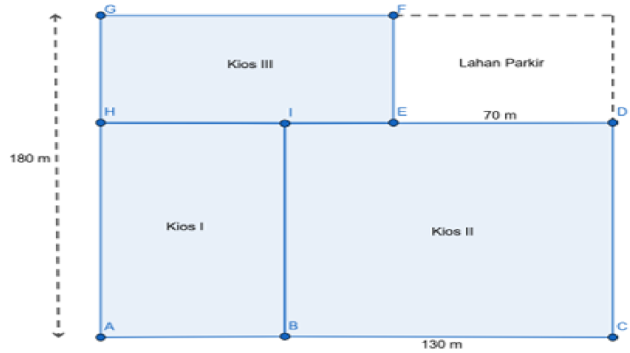
This research employed qualitative methods. This research employed a qualitative method with an exploratory approach. This method focuses on a comprehensive understanding of the processes and mechanisms underlying causal relationships through the collection and analysis of qualitative data. The research was conducted at a school in Cirebon, MTs As-Sidiqiyah. The participants were the target groups for data collection: students at the school who had already learned about linear equations in one variable. The subjects were students with left-brain and right-brain dominance, selected from the eighth-grade students of MTs As-Sidiqiyah.

The data collection techniques used were a Numeracy Test based on algebraic thinking processes, a Brain Dominance Test, and a Semi-Structured Interview. The Numeracy Test consisted of one question that met the Knowing, Applying, and Reasoning indicators. The Brain Dominance Test used was taken from the Brain Dominance Test used Tender (2000). Data collection was conducted by giving students numeracy problems to complete. The researcher recorded the students' progress. During the process, the researcher asked the students to express their thoughts aloud (think aloud). The researcher also recorded verbal expressions, noting expressions and interesting actions.

The instrument in this study was a brain dominance test, with the researcher as the primary instrument, guided by a task sheet consisting of numeracy questions, and enhanced by interviews. The numeracy questions used were competency level 4 (grades 7 and 8). The numeracy that must be mastered in the algebra component was taken fromCenter for Education and Training (2025) namely solving linear equations and inequalities in one variable and systems of linear equations in two variables. The following questions are used:

LAHAN PAK DUDUNG

Pak Dudung adalah seorang pembisnis yang berencana memperluas usahanya. Ia memiliki sebidang lahan kosong berbentuk persegi panjang yang terletak disebuah kota. Pak Dudung membeli tanah tersebut dengan harga $Rp. 3.000.000,-$ per m^2. Lahan tersebut akan dimanfaatkan untuk membangun tiga kios sederhana dan sebuah area parkir agar para pembeli merasa nyaman. Rencana kios-kios yang akan dibangun diberi nama Kios I, Kios II, dan Kios III yang disajikan seperti gambar berikut:



a. Berdasarkan data pada wacana diatas, maka pilihlah benar atau salah pada setiap pernyataan berikut! Sertakan juga jawabannya.

No	Pernyataan	Benar	Salah
1	Panjang DE adalah 80 m	○	○
2	Panjang DI adalah 130 m	○	○
3	Panjang EI adalah 60 m	○	○
4	Panjang AG sama dengan penjumlahan Panjang DC dan Panjang EF	○	○

b. Perhatikan bangun ABIH (Kios I). jika lebar Kios I adalah 40 m lebih pendek dari Panjangnya dan keliling kios I tersebut adalah 400 m, maka berapakah luas dari kios I?

c. Berdasarkan wacana diatas, Seandainya pak dudung ingin menjual Kembali lahan tersebut dengan harga $Rp. 3.500.000,-$ per m^2, maka berilah tanda centang pada pernyataan-pernyataan berikut yang bernilai benar!

1) ☐ Keuntungan penjualan kios I sebesar $Rp. 4.800.000.000,-$
2) ☐ Keuntungan penjualan kios II sebesar $Rp. 7.600.000.000,-$
3) ☐ Keuntungan penjualan kios III sebesar $Rp. 4.200.000.000,-$
4) ☐ Keuntungan penjualan jika seluruh lahan dijual adalah sebesar $Rp. 16.600.000.000,-$

Figure 1. Algebra component numeration questions

Researchers play a role in determining the research focus, selecting informants as data sources, collecting data, assessing data, assessing data quality, analyzing data, interpreting data, and drawing conclusions based on their findings. The data analysis technique used is the Miles & Huberman Model. This Miles & Huberman Model consists of data reduction, data presentation, and drawing conclusions.

C. Results and Discussion

The algebraic thinking process in solving numeracy problems can be observed through three main stages., namely extracting information from a situation (Pattern Seeking), presenting information mathematically (Pattern Recognition), and interpreting and applying mathematical findings (Generalization). This division is in line with the opinion of Kieran (2004) which explains that algebraic thinking is not only related to symbol manipulation, but also the ability to identify patterns, present mathematical representations, and interpret mathematical relationships in problem-solving contexts. In this study, these three stages were used to assess the extent to which students were able to develop algebraic thinking processes when faced with numeracy problems based on real-life contexts.

The Algebraic Thinking Process of Left-Brain Dominated Students

Based on the results of the answers and videos of students when working, students in working on the Knowing indicator in Numeracy questions begin writing down the information in the question and the questions asked. Students write down information about purchasing land for $Rp. 3.000.000, -per\ m^2$. However, they do not write down the information in the picture, such as the lengths of DE, BC, and AG. Students also write down what is asked according to the question. Students understand the question and then write down what they understand, and so on until the information they understand is written on the answer sheet.

After writing down the information in the question, students pause for a moment to understand the question first. Then, after getting an idea, students begin writing the answer to the question in part a. Students answer that statement number 1 is incorrect because the length of DE in the image is 70m, not 80m. This is shown in the following image:

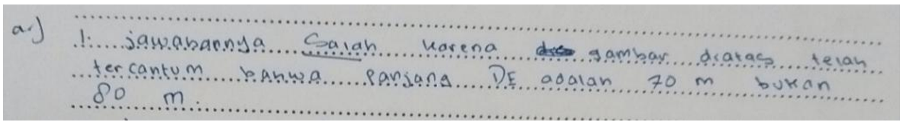

a.) 1: jawabannya Salah karena gambar diatas telah tercantum bahwa panjang DE adalah 70 m bukan 80 m.

Figure 4. The students' answers are dominated by the left brain in question part a statement 1

Students ask questions before answering statement 2. The questions are as follows:

S: The length of DE is 70m, what is the length of DI?
Q: What do you think?
S: The length of DI is the same as this length (while pointing to the length of BC which is 130m).

Then the students answered that statement number 2 was correct because based on the picture, the length of DI is the same as the length of BC, which is 130m. Students pause to understand the question first. Students also ask questions again before answering statement 3. The questions are as follows:

S: The length of DI is the same as the length of BC, so it is 130m minus 70m, right?
Q: That's right

Then the students answered that statement number 3 was correct because the length of EI was the result of the length of BC minus the length of DE, namely 130m minus 70m, resulting in 60m. Students pause to understand the question first. Then, they answer statement number 4 correctly because it can be seen in the picture that the length of AG is the same as the length of DC plus the length of EF. This is based on the following interview results:

Q: Try to explain what is meant by the words "seen by the DC and EF measurements"!
S: This means that the length of AG is equal to the sum of the lengths of DC and EF.

This is reinforced by the results of the students' answers as follows:

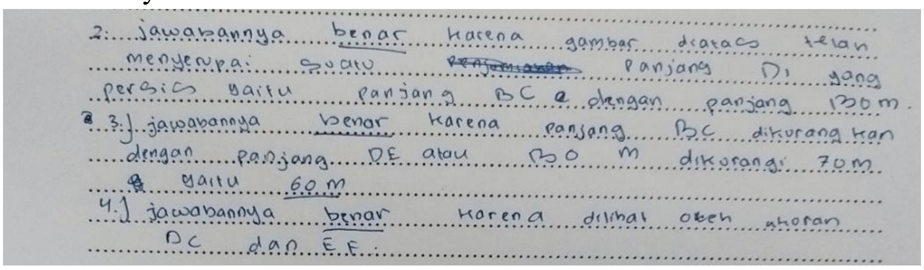

2: jawabannya benar karena gambar diatas telah menyertai suatu panjang Di yang persis yaitu panjang BC a dengan panjang 130 m.
3.) jawabannya benar karena panjang BC dikurang kan dengan panjang DE atau 130 m dikurangi 70 m yaitu 60 m
4.) jawabannya benar karena dilihat oleh ukuran DC dan EF.

Figure 4. The students' answers were dominated by the left brain in questions part a, statements 2, 3, and 4.

The results of the study show thatStudents describe their ability to extract important information from questions and identify variables.Students write down information about purchasing land for Rp. 3,000,000 per m2. At this stage, students demonstrate initial algebraic thinking skills through reading activities, sorting information, and determining what is known and what is asked in the problem. This activity aligns with mathematical literacy theory according to OECD (2023), that mathematical literacy begins with the ability to identify mathematical elements in a contextual situation. Students analyzed all statements correctly. Students completed the numeracy problems in the knowing indicator by analyzing the available images. In the research findings, although students did not write variable symbols such as p and l, students had actually selected which quantities were variables through an internal process, namely determining length and width as the main components to solve the problem. This indicates that the Pattern Seeking indicator has been achieved, because students were able to classify information and connect data with the objectives of the problem, as well as determine variables (Rahmawati et al., 2019). This first stage demonstrates that students can solve numeracy problems in the Knowing indicator. This means that students possess basic knowledge of facts, processes, concepts, and methods. Students' algebraic thinking processes in solving problemsby writing down the information in the questions and the things asked at the completion stage by extracting information from the situation (Pattern Seeking).

Students working on the Applying indicator in the Numeracy questions in part bby understanding the problem and then writing down what they understand. Then, they solve the problem. Students perform calculations by experimenting with the values, so the researcher wants to know what they are doing by asking:

Q: Why do you calculate like that? Try to explain.
S: Because the difference is 40m, 400m is subtracted from 40m twice, resulting in 320m, then divided by the 4 sides, resulting in 80m.
Q: What is the value of 80m?
S: This is the width. So if it is reduced to a square shape, the length should be added 40m because it was already reduced by 40m, so the length is 120m.

After carrying out the discussion session, students continued by checking the width and length values by adding (80m + 80m) + (120m + 120m) to produce a final value of 400m. This is in accordance with the problem where the circumference is 400m. Students concluded that the length and width are 120m and 80m respectively. Students then continued to solve the problem by calculating the area of Kiosk I using the concept of the area of a rectangle, namely $L = p$ x l. Students replaced the length value of 120m and the width of 80m so that the area of Kiosk I was 9.600m2. The results of the answers in part b can be seen in the following image:

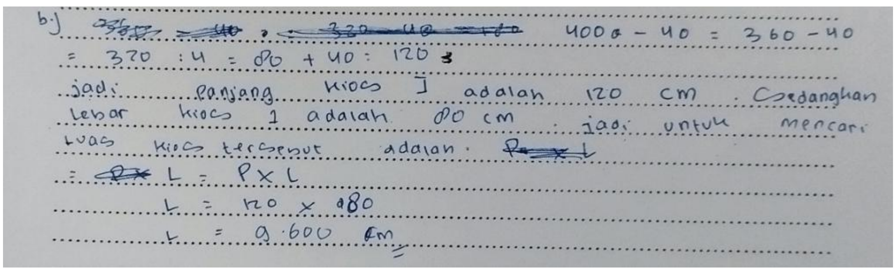


Figure 5. The students' answers were dominated by the left brain in part b of the questions.

The results of the study show thatStudents do not immediately write the symbols in variable form, but students break down the circumference into four sides, divide them evenly, then adjust them to the known difference in length and width.Students determine a mathematical model or equation based on the variables that have been determined by using the circumference formula, namely $K = p + p + l + l$ the result of the circumference must be 400m, and the difference between the length and width is 40m so that the mathematical model is $p - l = 40$. Students use the equation model to solve the problem. Students work with the concept that the circumference can be reduced by 40m twice because the difference between the length and width is 40m so that the result of the subtraction is divided by 4 equal sides of the length to produce 80m. then students find the length by 80m + 40m because the difference is 40m so that they get 120m. After that, students calculate the area of kiosk I using the concept of the area of a rectangle $L = p \text{ x } l$, which produces 9600m2. This process shows that students have recognized the pattern of relationships between quantities, as emphasized in the theory of algebraic reasoning which states that pattern recognition is the foundation of algebraic thinking (Blanton & Kaput, 2005). This second stage shows that students can solve numeracy problems on the Applying indicator. This means that students have the ability to implement facts, concepts, processes, and methods to solve problems. Students in working on the Applying indicator in Numeracy problems carry out an algebraic thinking process by presenting information mathematically (Pattern Recognition). Representations can be in the form of equations, mathematical expressions, structured calculations, or organizing data in the form of numerical operations. According to Kaput (2008), this ability is the core of algebraic activities, because students must be able to transform verbal or visual information into an operable mathematical structure.

Students working on indicators Reasoning in the Numeracy questions in part c, start by understanding the meaning of the questions in part c.Students understand the questions and then write down what they understand. Students complete part c of statement 1 starting by calculating the profit per m2. Students calculate the profit by subtracting the selling price per m2 from the purchase price per m2, which is Rp. 3.500.000,00 – Rp. 3.000.000,00, resulting in Rp. 500,000.00. Then students calculate the profit from selling Kiosk I by multiplying the area of Kiosk I by the profit per m2, which is 9600m2 x Rp. 500.000,00, resulting in Rp. 4.800.000,00. The results of this calculation make students conclude that statement 1 is true. This results in students analyzing correctly. Before continuing to work on the questions, students first asked the researcher. The questions were as follows:

S: Next, calculate the area of Kiosk II, okay?

Q: Yes, how?

S: Find the area of Kiosk II using the formula $L = p \text{ x } l$. The length of Kiosk II is 130m and the width is 120m, so the area of Kiosk II is calculated by multiplying 130m by 120m.

Students complete part c of statement 2 starting by calculating the area of kiosk II using the formula $L = p \text{ x } l$ is 130m x 120m which results in 15600m2. Then students calculate the profit per m2 in the same way as statement 1 which results in Rp. 500.000,00. Students calculate the profit from selling Kiosk II by multiplying the area of Kiosk II by the profit per m2, namely 15600m2 x Rp. 500.000,00 which results in Rp. 7.800.000.000,00. The results of this calculation make students conclude that statement 2 is true.

Students calculate the length by adding the lengths HI and IE to get 140m and the width by subtracting AG and DC to get 60m. This is supported by the following interview results:

Q: Yes, it is true. How to find the length and width?

S: The length is obtained from the sum of HI and IE, which is 60m plus 80m, resulting in 140m. Then, the width is obtained by subtracting AG and DC, which is 180m minus 120m, resulting in 60m.

Students complete part c of statement 3 starting by calculating the area of kiosk III using the formula $L = p \text{ x } l$ is 140m x 60m which produces 8400m2. Then students calculate the profit per m2 in the same way as statement 1 which results in Rp. 500.000,00. Students calculate the sales profit of Kiosk III by multiplying the area of Kiosk III by the profit per m2, namely 8400m2 x Rp. 500.000,00 which results in Rp. 4.200.000.000,00. The results of this calculation make students conclude that statement 3 is true. This results in students analyzing correctly.

Students begin to complete part c of statement 4 by adding up the profits from the sales of Kiosk I, Kiosk II, and Kiosk III, namely Rp. 4.800.000.000,00 + Rp. 7.800.000.000,00 + Rp. 4.200.000.000,00 which results in Rp. 16.800.000.000,00. Students make an error in completing this statement 4. Students do not calculate the area of the Parking Lot which is part of the entire land. This error causes students to make an error in their analysis. The results of the answers in part c can be seen in the following image:

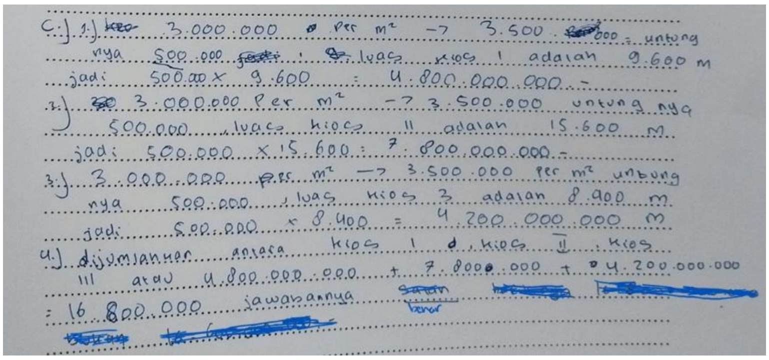


Figure 6. The students' answers were dominated by the left brain in part b of the questions.

The results of the study show that students are able to conclude three of the four statements correctly, showing that overall students have the ability to reason in the process of analyzing data, drawing conclusions, and understanding problems that are more complex than previous problems.. Although there is an error in one statement, it is more due to negligence in certain information, namely not calculating the parking area, rather than due to weaknesses in the algebraic process. Students in working on the Reasoning indicator in Numeracy problems are carried out an algebraic thinking process by interpreting and applying mathematical findings (Generalization). Students apply the variable values that have been found, namely Length 80m and Width 120m to find the correct solution to the problem (draw conclusions). Students use these variable values to find the area of each kiosk, namely kiosk I, kiosk II, and kiosk III. The area of each kiosk is used to find the solution to the problem, namely calculating the profit from the sale of land so that students are able to draw conclusions. This ability is in line with the opinion. Mason et al. (2005) Generalization is a high-level algebraic thinking activity that involves reflection on mathematical relationships. In the study, students were able to correctly conclude three of the four statements, demonstrating that they could apply variable values to various contexts. At this stage, students were able to solve numeracy problems in the Reasoning indicator by interpreting and applying mathematical findings (Generalization).

Based on the analysis results, it can be concluded that students are able to solve algebraic thinking-based numeracy problems through three main stages, namely Knowing, Applying, and Reasoning, each of which reflects the development of their algebraic thinking skills. In the Knowing stage, students successfully identify important information, understand what is known and asked, and extract information from the situation accurately so that the Pattern Seeking indicator is met. Next, in the Applying stage, students can transform verbal information into a mathematical model, construct an equation based on the relationship between length, width, and circumference, and operate the model to find the value of the variable, thus indicating the achievement of the Pattern Recognition indicator. In the Reasoning stage, students are able to use the variable values that have been obtained to complete further calculations, interpret mathematical relationships, and draw final conclusions, although there is one error due to omission of information, but this ability shows the achievement of the Generalization indicator. Overall, this process confirms that numeracy literacy does not only depend on the accuracy of calculations, but also on the ability to think systematically, structured, and reflectively in algebra in extracting information, representing mathematical models, and interpreting calculation results to produce meaningful solutions.

The Algebraic Thinking Process of Right Brain Dominant Students

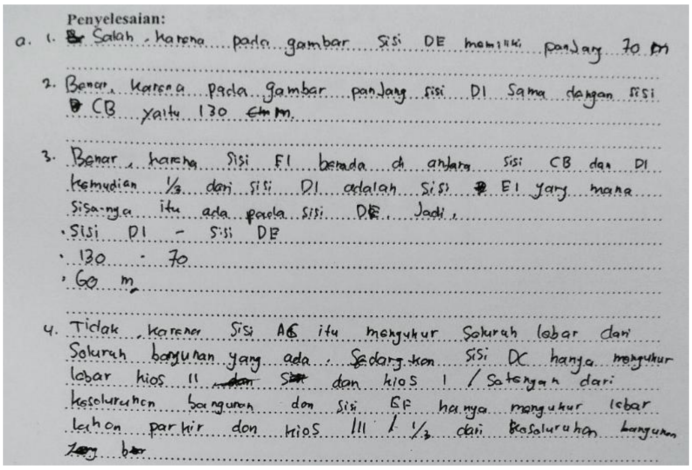
Based on the results of the answers and videos of students when working, students in working on the Knowing indicator in Numeracy questions withextracting information from the situation (Pattern Seeking). Students begin writing down the information in the problem and the questions asked $Rp. 3.000.000, -per\ m^2$. However, students do not write down the information in the picture, such as the lengths of DE, BC, and AG. Students write down what is asked according to the problem. Students read the problem as a whole. Students understand the problem as a whole first, then write down what they have understood. However, students do not determine the variables.

Students start working on part a by answering statement 1. Students answer that statement number 1 is wrong because in the picture the side DE has a length of 70m. Continued by answering statement 2, Students answer that statement 2 is correct because in the picture the length of side DI is the same as side CB which is 130m. Students pause for a moment to understand the question again. Students continue after understanding what to answer. Students answer statement 3 by writing that statement 3 is correct because side FI is between sides CB and DI, then one third of side DI is side EI where the remainder is on side DE so that side DI minus side DE which is 130m - 70m produces 60m. Then continued to answer statement 4. Students answer that statement 4 is wrong. Students argue that side AG is the length and width of the entire building, while side DC is the width of kiosk I and kiosk II or half of the entire building, then side EF is the width of the parking lot and kiosk III or one third of the entire building. Based on this, students are wrong in analyzing statement 4. The researcher wanted to know more about the reasons for the answers given by the students, so the researcher held a discussion with the students as follows:

Q: Why do you think that side DC is half the length of AG and EF is one third of the length of AG?

S: Because based on my observations, the length of DC is half of the length of AG and the length of EF is one third of the length of AG

Based on the discussion, students solved the problem in statement 4 using intuition. Intuitive problem-solving involves gaining understanding based on instinct, without going through a logical reasoning process. The results of the answers in part a can be seen in the following image:


Penyelesaian:
a. 1. Salah, karena pada gambar sisi DE memiliki panjang 70 m

2. Benar, karena pada gambar panjang sisi DI sama dengan sisi CB yaitu 130 m.

3. Benar, karena sisi FI berada di antara sisi CB dan DI kemudian 1/3 dari sisi DI adalah sisi EI yang mana sisanya itu ada pada sisi DE. Jadi,
• sisi DI - sisi DE
• 130 - 70
• 60 m

4. Tidak, karena sisi AG itu mengukur seluruh lebar dari seluruh bangunan yang ada. Sedangkan sisi DC hanya mengukur lebar kios II dan kios I / setengah dari keseluruhan bangunan dan sisi EF hanya mengukur lebar lahan parkir dan kios III / 1/3 dari keseluruhan bangunan

Figure 7. The students' answers were dominated by the right brain in part a of the questions.

The results of the study show thatStudents are described as having basic skills in knowledge of facts, processes, concepts, and methods. Students are required to complete the processAlgebraic thinking is accomplished by writing down the information in the problem and the questions asked in the solution stage by extracting information from the situation (Pattern Seeking). Students write down information about purchasing land for Rp. 3.000.000,- per m2. Students obtain information by answering numeracy questions in the Knowing indicator. Students analyze three statements correctly, but analyze one statement incorrectly. Students solve three numeracy questions in the Knowing indicator by analyzing the available images, while one statement uses intuition. Students can state general information such as the purchase price of land per meter, the shape of the building, and the structure of the kiosk division, but do not explicitly determine variables such as length and width. Although not writing down the variable symbols formally, students still demonstrate a pattern of recognizing important elements of the situation by constructing a mental image of the building and its parts. This activity fulfills part of the Pattern Seeking indicator, namely extracting important information from the situation, although it has not yet reached the level of variable abstraction as described. Rahmawati et al. (2019) This first stage shows that students can complete numeracy problems in the Knowing indicator.

Students work on the Applying indicator in the Numeracy questions in part b withRepresenting information mathematically (Pattern Recognition). Students perform calculations by experimenting with the values. Students begin by dividing the circumference by four, i.e ., 400m divided by 4, resulting in 100m for each length. Before continuing, students try several times with different numbers. After trying with several different numbers, the students get the correct results, namely 120m in length and 80m in width. This is reinforced by the results of the students' scribbles as follows:

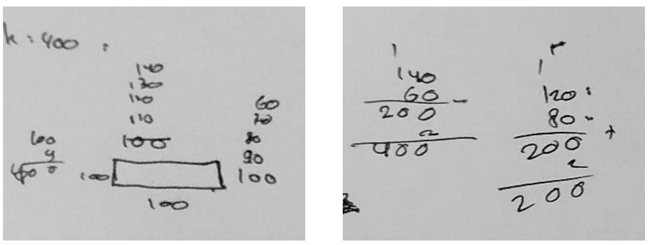


Figure 8. Students' scribbles are dominated by the right brain

Students then continue solving the problem by calculating the area of Kiosk I using the concept of the area of a rectangle, namely $L = p$ x l. Students replace the length value of 120m and width of 80m so that the area of kiosk I is 9.600m2. The results of the answer in part b can be seen in the following image:

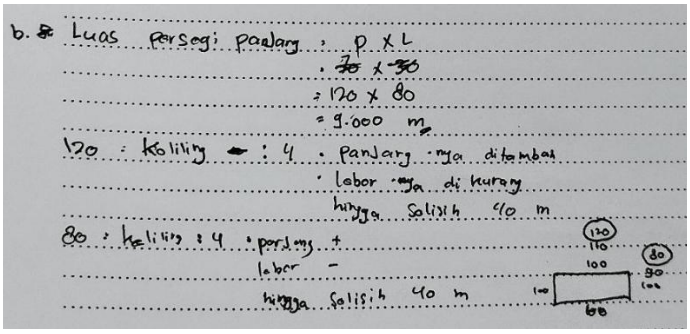


Figure 9. The students' answers were dominated by the right brain in part b of the questions.

The results of the study show thatStudents in working on the Applying indicator in Numeracy questions carry out an algebraic thinking process by presentingmathematically retrieve information (Pattern Recognition). Although mathematical modeling is not done symbolically, students are still able to produce pairs of Length and Width values that are consistent with the provisions of the problem. Students determine a mathematical model or equation based on predetermined variables using the circumference formula, namely $K = p + p + l + l$ the result of the circumference must be 400m, and the difference between the Length and Width is 40m so that the mathematical model is $p - l = 40$. Students use the equation model to solve the problem. Students work with the concept that the circumference can be divided first by 4 so that each Length produces 100m. Students add one of the sides which is then the Length of kiosk I and subtract one of the other sides which is then the width of kiosk I. Students try to find the Length and Width which must total 400m. Students find the Length and Width are 120m and 80m respectively. After that, students calculate the area of kiosk I using the concept of the area of a rectangle $L = p$ x l which produces 9600m2. This second stage shows that students can solve numeracy problems on the Applying indicator. This means students have the ability to implement facts, concepts, processes, and methods to solve problems. Students, when working on the Applying indicator in numeracy problems, engage in algebraic thinking by restating information mathematically (Pattern Recognition).

Students working on indicators*Reasoning*in the Numeracy questions in part c withinterpreting and applying mathematical findings (Generalization). Students complete part c of statement 1 starting by calculating the profit per m2. Students calculate the profit by subtracting the selling price per m2 from the purchase price per m2, which is Rp. 3.500.000,00 – Rp. 3.000.000,00, resulting in Rp. 500.000,00. Next, students calculate the profit from selling Kiosk I by multiplying the area of Kiosk I by the profit per m2, which is 80m2 x Rp. 500.000,00, resulting in Rp. 30.000.000,00. The results of this calculation lead students to conclude that statement 1 is false. Students made an error in completing statement 1. Students entered the wrong value for the area of Kiosk I, which is 80m2, when it should be 9600m2. This error resulted in students making an error in their analysis. This is reinforced by the results of the students' answers as follows:

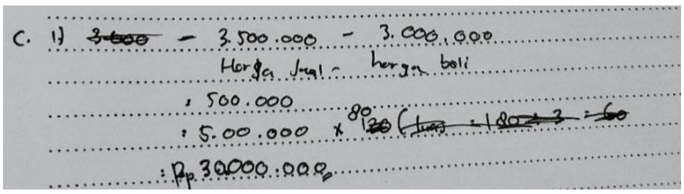


Figure 10. The students' answers by the right brain dominance in question part c, statement 1.

Students in completing part c of statement 2 begin by calculating the area of kiosk II using the formula $L = p \times l$ is 130m x 120m which results in 15600m2. Then students calculate the sales profit of Kiosk II by multiplying the area of Kiosk II by the profit per m2, namely 15600m2 x Rp. 500.000,00 which results in Rp. 7.800.000,00. The results of this calculation make students conclude that statement 2 is false. This results in students analyzing it correctly. This is reinforced by the results of students' answers as follows:

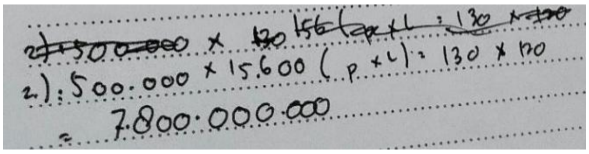


Figure 11. The students' answers dominated by the right brain in question part c, statement 2.

Before working on the questions, students first asked the researcher. The questions were as follows:

S: Does this mean the length of this (pointing to IE) is 60m and the length of HI is 80m?
Q: Yeah right, then?
S: The length of HE is the sum of HI and IE, namely 60m plus 80m, the result is 140m.
Q: How to find the width?
S: Finding the width resulting from subtracting AG and DC, namely 180m minus 120m, the result is 60m. So the result is 140m multiplied by 60m?

Students complete part c of statement 3 starting by calculating the Length of HE by adding the Length of HI and the Length of IE which is 80m + 60m resulting in 140m, then calculating the Length of HG by subtracting the Length of AG by the Length of DC which is 180m - 120m resulting in 60m. Next, students calculate the area of kiosk III using the formula $L = p \times l$ is 140m x 60m which results in 8400m2. Then students calculate the profit from selling Kiosk III by multiplying the area of Kiosk III by the profit per m2 which is 8400m2 x Rp. 500.000,00 which results in Rp. 4.200.000,00. The results of this calculation make students conclude that statement 3 is true. This results in students analyzing correctly. This is reinforced by the results of students' answers as follows:

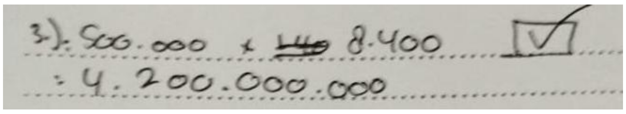


Figure 12. The students' answers dominated by the right brain in question part c, statement 3.

Students begin to complete part c of statement 4 by calculating the areaparking lot first. Students calculate the area of the parking lot using the formula $L = p \times l$ is 80m x 60m which results in 4200m2. Then students calculate the profit from selling the parking lot by multiplying the area of the parking lot by the profit per m2, which is 4200m2 x Rp. 500.000,00 which results in Rp. 2.100.000,00. Students find the total profit by adding up the profits from the sale of Kiosk I, Kiosk II, Kiosk III, and the parking lot, which is Rp. 30.000.000,00 + Rp. 7.800.000,00 + Rp. 4.200.000,00 + Rp. 2.100.000,00 which results in Rp. 14.130.000.000,00. Students make a mistake in solving this statement 4. Students understood the data analysis process, but errors occurred, leading to incorrect conclusions. These errors occurred because they incorrectly calculated the profit for kiosk I and the parking area, resulting in an error in calculating the total profit. This error resulted in incorrect analysis. This is supported by the following student answers:

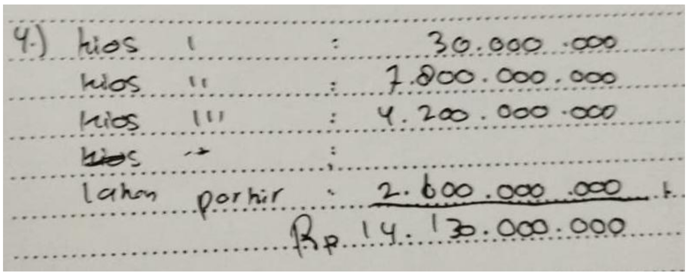


Figure 13. The students' answers dominated by the right brain in question part c, statement 4.

The results of the study show thatIn the third stage, Generalization, students were not fully able to solve the numeracy problems in the Reasoning indicator. Students made mistakes in analyzing statement 1 and statement 4. Statement 1 contained an error in understanding the area of kiosk I. The area of kiosk I should be 9600m2. Statement 4 contained an error in calculating the profit of kiosk I and the calculation of the parking area, resulting in an error in calculating the total profit. Based on this, overall, students have sufficient ability to reason in the process of analyzing data, drawing conclusions, and understanding problems that are more complex than the previous problem. Students in working on the Reasoning indicator in the Numeracy problem in part c carried out an algebraic thinking process by interpreting and applying mathematical findings (Generalization). Students were sufficiently able to apply the variable values that had been found, namely Length 80m and Width 120m to find the right solution to the problem (draw conclusions). Students used these variable values to find kiosk II, kiosk III, and the parking area. The area of kiosk I and kiosk II is used to find solutions to problems in statements 2 and 3, namely calculating the profit from selling land so that students are able to draw conclusions from these statements, however, students cannot draw conclusions correctly from statements 1 and 4. This error is caused by an intuitive reasoning process that relies too much on visual images of parts of the image, without building mathematical relationships. Mason et al., (2005) explains that generalization in algebraic calculations requires the ability to reflect the structure of mathematical relationships explicitly.

Based on the results of the analysis, it can be concluded that students are able to solve numeracy problems based on algebraic thinking through three main stages, namely Knowing, Applying, and Reasoning, which each reflects the development of their algebraic thinking skills. In the Knowing stage, students successfully identified important information, understood what was known and asked, and extracted information from the situation appropriately so that the Pattern Seeking indicator was met. Next, in the Applying stage, students were able to determine a mathematical model or equation based on predetermined variables based on the relationship between length, width, and circumference, and operate the model to find the variable values, thus demonstrating the achievement of the Pattern Recognition indicator. In the Reasoning stage, students used the obtained variable values to complete further calculations, interpret mathematical relationships, and draw final conclusions. Students correctly completed two statements and incorrectly completed two statements. Thus, overall, students have sufficient reasoning skills in the process of analyzing data, drawing conclusions, and understanding problems that are more complex than the previous problem.

Differences in the Thinking Processes of Left-Brain and Right-Brain Dominant Students in Solving Numeracy Problems

Based on the discussion above, left-brain and right-brain dominant students have several differences in their thinking processes at each stage of solving algebraic-based numeracy problems. These differences begin to appear at the Knowing stage, which is related to the ability to extract information from the situation (Pattern Seeking). Both students are equally able to identify important information contained in the problem and understand what is known and what is being asked. However, left-brain dominant students identify information more systematically by connecting it to previously learned mathematical concepts. In contrast, right-brain dominant students build understanding more through observing visual representations in images without explicitly determining variables. As a result, right-brain dominant students tend to use intuitive reasoning when interpreting relationships between parts of a figure, resulting in an error in one of the statements. Nevertheless, both students are still able to meet the Knowing indicator because they successfully extract most of the information needed to continue the problem-solving process.

Differences in thought processes are also evident in the Applying stage, which is related to the Pattern Recognition indicator. Left-brain-dominated students construct a structured mathematical model by determining the relationship between length, width, and perimeter before performing calculations to obtain variable values. This approach demonstrates that students use mathematical relationships as a basis for constructing a solution model, allowing the calculation process to proceed systematically. In contrast, right-brain-dominated students obtain variable values through a trial-and-error strategy, trying several possible length-width pairs until they meet the problem's conditions. Although this strategy ultimately yields the correct variable values, the solution process relies more on exploring various possibilities than directly forming a mathematical model. After obtaining the variable values, both students are able to use the model to calculate the area of the first kiosk, thus still achieving the Applying indicator.

The most obvious difference emerged in the Reasoning stage, related to the Generalization indicator. Left-brain-dominated students were able to correctly apply the obtained variable values to solve almost all of the problems and made only one error due to not calculating the parking area. This error was more due to the omission of certain information than a failure to establish mathematical relationships. In contrast, right-brain-dominated students made errors in two problems due to errors in using previous calculation results and a tendency to maintain intuitive reasoning throughout the solution process. Although right-brain-dominated students successfully determined the correct variable values in the Applying stage, the generalization process was not carried out consistently when applying these values to more complex situations. This condition indicates that Generalization ability depends not only on the accuracy of obtaining variable values, but also on the ability to consistently maintain mathematical relationships until the conclusion stage. Overall, left-brain-dominated students demonstrated a more systematic and consistent algebraic thinking process in the Knowing, Applying, and Reasoning indicators. In contrast, right-brain dominant students show more flexible and intuitive thinking processes, but their reasoning consistency decreases when they have to integrate several pieces of mathematical information at once to produce a final conclusion.

D. Conclusion

The algebraic thinking process of left-brain-dominated students in solving numeracy problems is strongly influenced by the dominance of the cerebral hemisphere, as seen in the Knowing, Applying, and Reasoning stages of thinking. In the Knowing stage, students successfully identify important information, understand what is known and asked, and extract information from the situation appropriately so that the Pattern Seeking indicator is met. Furthermore, in the Applying stage, students can transform verbal information into a mathematical model, construct equations based on the relationship between length, width, and circumference, and operate the model to find variable values, thus indicating the achievement of the Pattern Recognition indicator. In the Reasoning stage, students are able to use the variable values that have been obtained to complete further calculations, interpret mathematical relationships, and draw final conclusions, although there is one error due to omission of information, but this ability shows the achievement of the Generalization indicator.

The algebraic thinking process of right-brain-dominated students in solving numeracy problems is strongly influenced by the dominant hemisphere of the brain, as seen in the Knowing, Applying, and Reasoning stages of thinking. In the Knowing stage, students successfully identify important information, understand what is known and asked, and extract information from the situation appropriately so that the Pattern Seeking indicator is met. Next, in the Applying stage, students can determine a mathematical model or equation based on predetermined variables based on the relationship between length, width, and circumference, and operate the model to find the variable value, thus indicating the achievement of the Pattern Recognition indicator. In the Reasoning stage, students use the variable values that have been obtained to complete further calculations, interpret mathematical relationships, and draw final conclusions. Students correctly solve two statements and incorrectly solve two statements. Thus, overall, students have sufficient ability to reason in the process of analyzing data, drawing conclusions, and understanding problems that are more complex than the previous problem.

Left-brained and right-brained students have different thought processes in solving numeracy problems in each algebraic thinking indicator, namely Pattern Seeking, Pattern Recognition, and Generalization, which are in line with the numeracy indicators of Knowing, Applying, and Reasoning. Left-brained students tend to use more systematic and consistent thought processes in identifying information, building mathematical models, and applying calculation results to draw conclusions. In contrast, right-brained students rely more on visual understanding, intuition, and exploration of various alternative solutions, so their thought processes are more flexible, but less consistent when integrating various mathematical information at the reasoning stage.

This study has several limitations. First, the limited number of research subjects, drawn from only one school, means the results cannot be generalized to a wider population. Second, the use of a qualitative approach allows researchers to gain a deep understanding of students' thought processes, but is unable to describe general trends in thought processes based on brain dominance in a larger population. Nevertheless, this study contributes to the development of studies on the relationship between brain dominance and thought processes in solving numeracy problems, particularly through the analysis of algebraic thought processes, which are still relatively rarely studied in depth. Therefore, it is recommended that further research examine a wider range of subjects, and then the study of brain dominance can be expanded to include various types of mathematical thought processes, such as critical, analytical, reflective, creative, and mathematical reasoning.

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