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# MATHEMATICAL LATERAL THINKING OBSTACLES IN SOLVING GEOMETRIC PROBLEMS BASED ON BRAIN DOMINANCE

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## Abstract

Creative thinking was characterized by the emergence of new ideas which was an important skill for students. Lateral thinking was one way to grow new ideas. Generally, related research was carried out to see the thinking process and its level only with the results of the majority of low levels (especially in geometry problems), so further research was needed to find out what were the obstacles. This study aims to find mathematical lateral thinking barriers based on brain dominance. This research was a qualitative research with a case study approach. The instruments were a brain dominance test, creativity questions, and geometry questions for lateral thinking. Triangulation of data collection techniques was carried out To ensure data validity. Obtained two main subjects LCS and RCS. Analysis of subjects' answers, interview and observations transcripts were carried out by coding the inhibiting factors then analyzed by Toulmin's arguments analysis. We findings that left-brain dominant student experience ontogenic barriers in finding something new caused bounded by concepts and right-brain dominant student experience epistemological barriers in finding different ways cause bounded by context. Further research was needed with students who have high mathematical abilities and creativity to find out how to overcome lateral thinking obstacles.

**Keywords**: Brain dominance; geometric problems; lateral thinking obstacle; Toulmin model

## *Abstrak*

*Berpikir kreatif ditandai dengan munculnya ide-ide baru yang merupakan keterampilan penting bagi siswa. Berpikir lateral adalah salah satu cara untuk menumbuhkan ide-ide baru. Umumnya penelitian terkait dilakukan untuk melihat proses berpikir dan tingkatannya saja dengan hasil sebagian besar tingkat rendah (khususnya pada masalah geometri), sehingga diperlukan penelitian lebih lanjut untuk mengetahui apa saja kendalanya. Penelitian ini bertujuan untuk menemukan hambatan berpikir lateral matematis berdasarkan dominasi otak. Penelitian ini merupakan penelitian kualitatif dengan pendekatan studi kasus. Instrumen yang digunakan adalah tes dominasi otak, soal kreativitas, dan soal geometri untuk berpikir lateral. Triangulasi teknik pengumpulan data dilakukan untuk menjamin keabsahan data. Diperoleh dua mata pelajaran utama LCS dan RCS. Analisis jawaban subjek, transkrip wawancara dan observasi dilakukan dengan mengkodekan faktor penghambat kemudian dianalisis dengan analisis argumen Toulmin. Kami menemukan bahwa siswa dominan otak kiri mengalami hambatan ontogenik dalam menemukan sesuatu yang baru disebabkan dibatasi oleh konsep, dan siswa dominan otak kanan mengalami hambatan epistemologis dalam menemukan cara yang berbeda karena dibatasi oleh konteks. Diperlukan penelitian lebih lanjut dengan siswa yang memiliki kemampuan dan kreativitas matematis tinggi untuk mengetahui cara mengatasi hambatan berpikir lateral.*

***Kata kunci**: Dominasi otak; masalah geometri; hambatan berpikir lateral; model Toulmin*

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## INTRODUCTION

Creative thinking was one of the learning objectives in the 21st century and is one of the mathematical thinking skills that need to be developed in students (Martin, 2000; P21, 2019). Being able to come up with or find new ideas is one of the characteristics of creative thinking. Lateral thinking is one way of generating new ideas (Edward De Bono, 2010; Lamb et al., 2015; White, 1972). As a way to come up with new ideas, Indonesian students are expected to have good lateral thinking skills. Many studies have been conducted in Indonesia, mostly on lateral thinking processes, levels of lateral thinking, and how to improve lateral thinking (Herman & others, 2019; Julita, 2019; Srikongchan et al., 2021; Susilawati et al., 2019). The results of some of these studies concluded that students' lateral thinking skills were still low, students were not familiar with lateral thinking questions. From some of these studies, one of the further research that is urgently needed is how to create new ideas so that the level of students' mathematical lateral thinking increases.

Several studies related to increasing students' lateral thinking skills concluded that the application of cognitive conflict learning strategies (Susilawati et al., 2019), reciprocal teaching strategies (Priatna, 2018), and Problem Based Learning (Mustofa & Hidayah, 2020) able to improve students' lateral thinking skills. However, from these studies, no one has focused on seeing the thinking barriers experienced by students. Even though, based on a preliminary study conducted by researchers in 2022, obtained that students' mathematical lateral thinking abilities were still very low and the mathematics teacher's theoretical knowledge of lateral thinking was also low (Lukman Jakfar Shodiq et al., 2022). This is probably because there has been no research related to the barriers to lateral thinking processes experienced by students. According to Brousseau (2006) there are three types of barriers to learning, namely ontogenic obstacle (limited lack of knowledge of context or maturity), didactical obstacle (limitation due to teaching), and epistemological obstacle (limited concept knowledge)". Based on the empirical and theoretical facts above, there is an urgency for research related to students' lateral thinking barriers, especially in the field of mathematics with the hope that the teacher can provide appropriate and effective treatment to students in learning so that their lateral thinking skills increase.

Mathematical lateral thinking problems are problems that are able to provide a leap of thought for students, provide various alternative answers, provide answers that are unusual, and trigger the use of random ideas to generate new ideas (E De Bono, 2014). Geometry is one of the junior high school math topics that is considered difficult and the majority of students are in the prelevel category (Chen et al., 2021; Prayito et al., 2019). Geometry learning is very important because it can be applied more widely to various scientific fields and various subjects in everyday life and is a significant predictor of showing creativity (Adnan et al., 2019; Schoevers et al., 2022). Therefore, it will be an interesting combination if an in-depth study is carried out on students' lateral thinking barriers on geometry problems.

In implementing a learning strategy, it is necessary to identify and profile students so that the treatment

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given is targeted and effective (Zaina & Bressan, 2008). There are various kinds of student profiles that can be reviewed in learning mathematics, for example learning styles (audio, visual, kinesthetic), cognitive style (field dependent, field independent), brain dominance (right brain, left brain, balanced) (Solso et al., 2005). To determine the student profile, instruments require special and in-depth analysis. Specifically to determine the profile of brain dominance, there are relatively easy and short instruments through quick tests, clasp your hands or cross your leg, and draw a circle. Thus, research related to brain dominance will make it easier for teachers to identify student profiles, so that teachers can give appropriate and appropriate treatment to students in learning because brain dominance affects student achievement in learning (Khotimah et al., 2022; Lusiana et al., 2020; Mansour et al., 2017; Singh, 2015).

Several empirical studies and literature above illustrate that there is urgency in research on lateral thinking barriers experienced by junior high school students in solving geometry problems in terms of right brain or left brain dominance. To obtain a more general picture, subjects were selected from junior high school students with an average level of ability in the fields of mathematics and creativity. Furthermore, to find students' mathematical lateral thinking barriers, an analysis was carried out using Toulmin's global argument method (Nielsen, 2013; Toulmin, 2003). So based on the urgency above, some specific objectives of this research can be derived, namely (1) What are the barriers to lateral thinking processes for left-brain-dominated junior high school student with average math skills and creativity in solving geometric problems?, (2) What are the barriers to lateral thinking processes for junior high school student with right brain dominance with average math skills and creativity in solving geometric problems!

## METHOD

This research was carried out with a qualitative research design with Toulmin's argumentation analysis model and descriptive analysis. There were three main stages in this research, namely the stage of subject selection, data collection, and analysis (Figure 1).

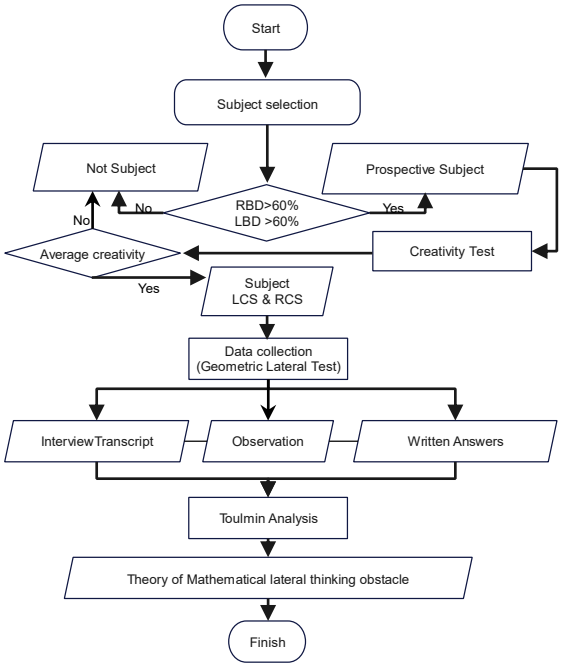


Figure 1. The stages of research

### *Subject Selection*

There were two steps in the selection of subjects, firstly, subjects with average mathematical abilities are collected and given a brain dominance test, students with right-brain dominant (RBD) or left-brain dominant (LBD) test results more than 60% will be prospective subjects, then the prospective subject was given a follow-up test in the form of two lateral thinking

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geometry questions developed by the researcher and had gone through a question validation process, as well as 9 questions to measure creativity based on TTCT (Kim, 2011). This test resulted in two subjects as right creative student (RCS) and left creative student (LCS).

***Data Collection***

The second stage was data collection, in the form of lateral thinking process data sourced from RCS and LCS answers on two geometry questions, interview data and observations based on interviews and observations of researchers on subjects to validate the data through triangulation of data collection techniques (Flick, 2004) which is then analyzed with the Argumentation Toulmin Model to find the theory of barriers to students' lateral thinking processes. To find out the obstacles experienced by students, it was used only two type based on Brousseau's criteria, namely ontogenic obstacle, and epistemological obstacle.

Participants in this study selected schools with average students' mathematical abilities in Lumajang Regency, East Java. There were 16 prospective subjects who then obtained 2 students who fit the criteria, namely the male students of class VIII. Data taken in May 2022. To obtain valid data, a data collection instrument that has gone through validation was developed. Validation was carried out on lecturers in the field of geometry and lateral thinking skills, and on junior high school mathematics teachers as practitioners of learning mathematics.

***Analysis***

Based on the research objectives, to obtain valid theoretical findings in this case study, an analysis was carried out using the Toulmin argumentation model as pictured in figure 2. Sources of data were obtained from students' answers to the two geometry questions given, interviews, and observations while the research subjects were working on the questions.

The general idea or finding of an argument consists of tracing the statement to re-proven the conclusion to an undoubted statement in the form of "**data**". This relationship was stated in the first line in figure 2 and it all leads to the conclusion of the "**claim**" argument. Such a conclusion requires legitimacy, a statement that contributes to it is called a **warrant**. Another statement that refers to the permissibility of warrants, Toulmin (2003) calls it "**backing**". Backing consists of facts that are accepted without question, which are specific to the field of arguments for the validity and justification of warrants. Statements that describe cases where warrants are invalid are "**rebuttal**" (Conner et al., 2014). Disclaimers include counter-examples or conditions under which the argument needs to be replaced. Arguments can be chained together in such a way that the accepted conclusion can serve again as data for the next new argument (Krummheuer, 2015).

Argument analysis in solving this problem will be used to find the thinking barriers experienced by students in fulfilling the four principles of lateral thinking according to De Bono (2014) namely recognizing the dominant idea of the problem at hand, looking for different ways of looking at the problem, loosen the rigid mind; and using random ideas to come up with something new.

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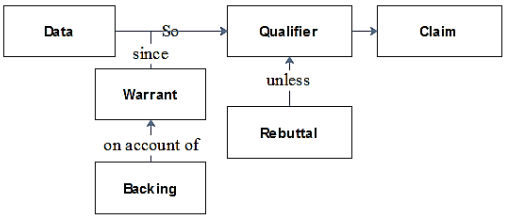


Figure 2. Toulmin's argumentation analysis

## RESULT AND DISCUSSION

### *Research Subject*

The main focus of this research was to find the learning barriers experienced by junior high school students with math skills and average level of creativity in solving geometric lateral thinking problems. From 16 subjects of junior high school students with average mathematical ability, 6 students were obtained as prospective subjects after doing a brain dominance test. From these 6 students, two main research subjects were obtained after the answers to the lateral thinking and creativity test were corrected.

The characteristics of the subjects obtained are described as in table 1 that is obtained two main subjects with the initials YR and LPR, both of which are male. The brain dominance of YR subjects is 70% left brain and 30% right brain so that the subject code is LCS, while the brain dominance of LPR is 36% left brain and 64% right brain so that the subject code is RCS. Both of these subjects have average mathematical abilities obtained from class teacher data, and have average creativity levels based on creativity tests given by researchers.

Table 1.Subjects characteristics

| Initials | Gender | Brain Domination | Subject Code |
|---|---|---|---|
| YR | Male | Left: 70%<br>Right: 30% | LCS |
| LPR | Male | Left: 36%<br>Right: 64% | RCS |

### *LCS' lateral thinking process*

Subjects who have been selected as left-brain-dominated students are given questions of mathematical lateral thinking in the context of geometry. This aims to find out how left-brain dominant students solve mathematical lateral thinking problems. The results of student answers are illustrated in figure 3 and 4.

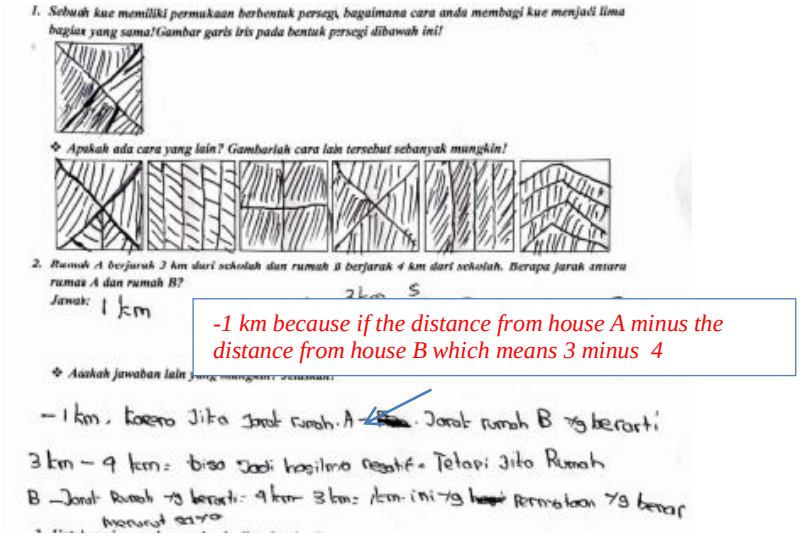


Figure 3. LCS's answers in solving geometrical problems

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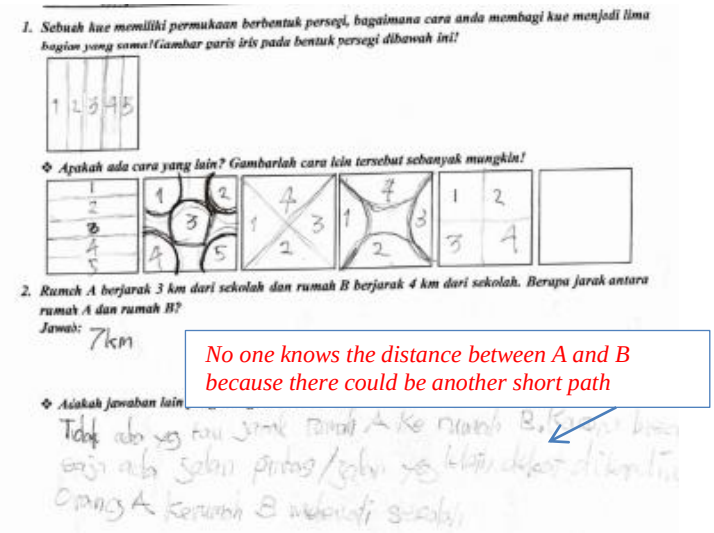


Figure 4. RCS's answers in solving geometrical problems

LCS worked on questions number 1 and 2 quietly. In working on problem number 1 based on figure 4, LCS first divides the square into 4 parts by making a cut line in the form of a square diagonal. In the follow-up question to find another way, students found 1 correct answer by cutting with a vertical line and one wrong answer by dividing the square into 5 triangles with unequal area. Because students got stuck, the researcher asked RCS to divide the square into 4 parts, the result was that LCS found 3 correct answers and made 1 wrong answer. In question number 2, LCS answered 1 km which was obtained from 4 km minus 3 km.

### *RCS' lateral thinking process*

The second subject who was selected as a student with right brain dominance was given a question of mathematical lateral thinking in the context of geometry. This aims to find out how students who are right-brained in solving mathematical lateral thinking problems. The results of student answers are illustrated in figure 4.

RCS worked on questions number 1 and 2 calmly and faster than LCS. Based on figure 4, RCS can find the correct answer in the first step of question number 1, but there is 1 unique answer, namely dividing the square into 5 equal parts with the circle model. Due to the deadlock of answers, the researcher asked a follow-up question what if the square was divided into 4 equal parts. Two correct answers were obtained and one column was empty because RCS had had enough and did not want to try to find another solution. In question number 2, RCS answered that the distance between A and B was 7 km from 3 + 4, and when asked if there was another possibility, RCS said that no one knows the distance between A and B because there are many possibilities, there could be a shortcut that connects A and B.

### *Toulmin's Argumentation in Solving Problem 1*

According to Brousseau (2006), there are three types of obstacles in learning, namely ontogenic obstacles, didactical obstacles, and epistemo-logical obstacles. This research does not look at the learning process that students go through, so it can only see ontogenic obstacles and epistemological obstacles. Problem number 1 is a

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geometry problem that requires students to understand the concept of fractions, and the concept of the area of a flat shape, besides that students also have to understand the context of parts of a flat shape. Based on the results of the answers, observations, and interviews, it can be analyzed using the Toulmin Argument-ation model in figures 5 and 6 to find the lateral thinking barriers faced by the RCS and LCS. In this case, it was found that there was a significant difference in lateral thinking processes and thinking barriers experienced by students with right-brain and left-brain dominance, in line with the research of ÜNAL ASLAN et al. (2021).

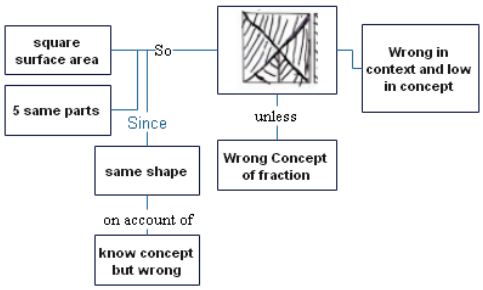


Figure 5. Toulmin's argumentation of LCS in problem 1

Figure 5 is an analysis of Toulmin's argument from LCS. LCS got the dominant idea in the form of a square-shaped surface and 5 equal parts (data), because of the same shape (warrant) and supported by wrong conceptual knowledge (backing), then LCS produced the wrong answer (qualifier) because there was an error in the concept of fractions (rebuttal) so that it is concluded that LCS has lateral thinking barriers due to wrong context and weak in concept (claim). On the principle of Dominant Idea, initially LCS did not understand and was bound to the general thought process, namely dividing a square into 4 parts, even though they were asked to divide it into 5 parts. On the principle of Different Way, the obstacle experienced by LCS is that it is not able to bring up a leap of thought because it is bound by the concepts understood, which are related to the concept of fractions and tend to maintain the same shape.

When interviewed, the LCS subject said that he was not sure about the answer and did not understand the question. Although unsure, LCS subjects tend to be calm in solving problems. The principle of Flexibility and Something New did not appear, this may be due to lack of experience with open questions. This is proven accor-ding to the interview transcript, LCS said that in looking for ideas using imagination and from everyday expe-rience, according to the findings of Tamba & Saragih (2020), the episte-mological barriers were related to knowledge experience. Another possibi-lity is that students with left brain dominance tend to think conver-gently and analytically (Wang et al., 2007).

The following is the conclusion from the transcript of interviews with RCS and LCS, namely that RCS better understands the subject matter. RCS realized that the problems given had many solutions, LCS felt confused and doubtful. Finally, in generating ideas, RCS feels that ideas appear suddenly, which is different from LCS which seeks ideas based on experience.

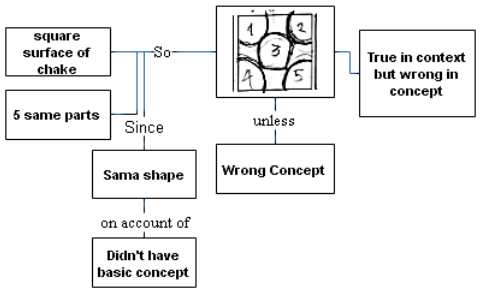


Figure 6. Toulmin's Argumentation of RCS in Problem 1

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Toulmin's argumentation scheme from RCS's answer in solving problem number 1 can be seen in figure 6. RCS got the dominant idea in the form of a square cake surface and 5 equal parts (data), because the shape is the same (warrant) and supported does not have conceptual knowledge (backing), then RCS produces the wrong answer (qualifier). because there is an error in the concept of fractions, but it is correct in context (rebuttal) so that it is concluded that RCS has lateral thinking barriers due to wrong concepts (claims). According to Shodiq et. al. (2021), the error in the concept of fractions, apart from the dominance of the brain, can also be caused by math anxiety.

To find the dominant idea of the problem, RCS does not experience obstacles and can understand it well. RCS was able to find different ways but there is a theoretical error when dividing a square into 5 equal parts in the form of a circle. Empirically correct, but theoretically wrong because there is still a remainder of the square. Thinking Flexibility has been seen with an unusual answer so that the RCS subject has found Something New but is still wrong in the concept. In general, this was the same as the research findings of Lusiana & Andari (2022) which concluded that students with right-brain dominance were able to find unique answers but students with right-brain dominance did not find them in solving algebraic problems.

### *Toulmin's Argumentation in Solving Problem 2*

In question number 2, it has a question indicator to understand the concept of the distance between two points and the locus of several objects. In addition, students must also be able to distinguish the context of the questions given and be able to find various possible object positions. Based on the results of answers, observations, and interviews, it can be analyzed using the Toulmin Argumentation model in figures 7 and 8 to find the lateral thinking barriers of RCS and LCS.

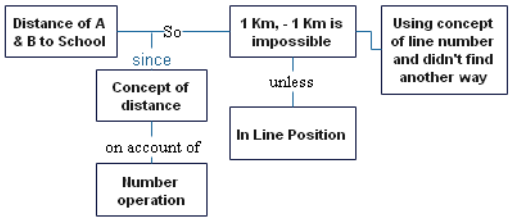


Figure 7. Toulmin's argumentation of LCS in problem 2

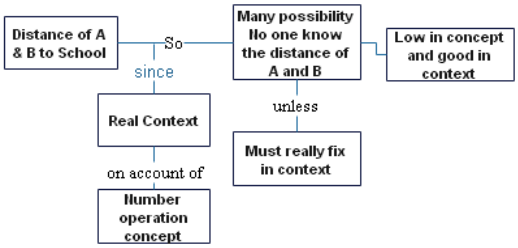


Figure 8. Toulmin's argumentation of RCS in problem 2

Based on Figure 7, LCS got the dominant idea in the form of distance A and B to school (data), because it already has the concept of distance (warrant) and is supported by knowledge of number operations (backing), then LCS produces a new unique answer (qualifier) because of the concept limitations. the distance is always in a straight line position (rebuttal) so it is concluded that LCS has lateral thinking barriers because it is bound by the concept (claim). Figure 8 explains that RCS got the dominant idea in the form of distances A and B to school (data), because armed with a real context (warrant) and supported by the concept of number operations (backing), then RCS produced the right idea but was unable to provide an

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answer (qualifier) because bound by context (rebuttal) so that it is concluded that RCS has lateral thinking barriers due to a weak concept (claim).

LCS subjects and RCS subjects have some similarities in solving problem number 2, namely on the principle of Dominant Idea both do not experience obstacles, according to the research of Firdiana et al. (2022) which concludes that male students are relatively fluent and thorough in working on geometry problems. In addition, the two subjects have almost the same mathematical ability, so the possibility of obtaining dominant ideas is also in the same category as the results of Kusumah et al. (2020) who said that mathematical ability had a significant effect on learning geometry.

Some differences occurred when searching for Different Way, both of them found answers that were more than 1 and different, this finding was the same as the finding of Yuwono et al. (2019) in his research on solving analytic geometry problems which stated that the rest of the men found two alternative solutions. LCS found an answer of 1 km and -1 km and RCS found an answer of 7 km and no one knows the distance between A and B. From the alternative answers given, some answers are wrong. Both of them are tied to the position of house A, house B, and school which must be in line. This is probably because both subjects have low working memory capacity which hinders processing and sorting out a lot of information in solving problems (Palengka et al., 2019, 2021). In thinking Flexibility, RCS is more flexible than LCS, LCS tends to be tied to the concept of a number line and RCS tends to be more flexible because it considers the real context but is weak in conceptual understanding regarding the distance between two points. This is in accordance with the results of research by Pavlova (2015) who said that productive and creative thinking is a combination of the left "ideal" and the right "real" hemisphere.

The findings on the LCS were in line with the findings Tendero (2000) and Singh (2015) which states that analytical thinking is a characteristic of students with left-brain dominance. As for RCS students, in the dominant aspect, ideas tend not to experience obstacles because they do the memory first and then they tend to read the whole question (Jensen, 2000). In addition, when bringing up aspects of flexible thinking and finding something new, RCS tends to pay attention to components as a whole and not separate or better known as holistic thinking (Hildebrand et al., 2019; Ju, 2015) and this is in line with the findings of Singh (2015), which states that holistic thinking is a feature of the function of the right hemisphere of the brain. However, in holistic thinking, RCS subjects experienced obstacles because they were weak in the concept of fractions, flat shapes, and the concept of distance between two points. In contrast to the LCS subjects who did not find new ideas because they were bound by their conceptual knowledge. This difference may also be influenced by the metacognitive ability of the LCS and RCS as the findings of the research of Aburayash (2021) which explains that there was a significant difference between right-brain and left-brain dominant subjects in terms of their metacognitive abilities. In addition, the subject's mathematical talent in the average category also affects mathematical creativity according to research by Assmus & Fritzlar (2022).

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Based on the discussion above, the main results of this study were presented in Table 2, which is a summary description of the learning barriers experienced by students in lateral thinking in terms of student brain dominance. The distinguishing aspect of learning barriers or thinking barriers was seen from the aspect of de Bono's lateral thinking.

Table 2. LCS and RCS obstacles

| Geometry Problem | Lateral Thinking Principles | LCS | RCS |
|---|---|---|---|
| Five same part of a square | Dominant Idea | Lack of understanding | No obstacle |
| | Different Way | Limited to flat shapes | Limited to the same size |
| | Flexibility | Weak in the concept of fractions | Wrong in the concept of fractions |
| | Something New | Weak in context | Weak in concept |
| Distance of A and B | Dominant Idea | No obstacle | No obstacle |
| | Different Way | The position of the object is always in line | Must be in really real context |
| | Flexibility | Do not use other concepts | Don't wanna try |
| | Something New | Concept bound | Context bound |

## Findings

Based on Table 2, it is finally found that the lateral thinking obstacles in solving geometry problems of left-brain dominant subjects (LCS) were experiencing obstacles to find new ways because they are limited by conceptual knowledge so that they are less able to think flexibly (because knowledge of concepts is weak) so it is difficult to find new ideas because they are too tied to conceptual knowledge. This finding is not in line with the findings of Khotimah et al. (2022) that left-brain dominant students have mathematical adaptive reasoning abilities at a high level. This is due to differences in research subjects, but this study is in line with the findings of Bunge & Leib (2020) that students with left brain preferences do things systematically, and linearly (limited by conceptual knowledge).

Right-brain dominant (RCS) subjects experienced obstacles in finding new ways because they were too contextual in thinking so that there was an error when flexible thinking (because the concept knowledge was wrong) so that it was difficult to find new ideas because they were too tied to contextual problems. This conclusion is in accordance with the results of Pamungkas et al. (2018) and Lusiana et al. (2020) that students with a right brain dominant level of metacognitive ability are aware of use and strategic use where in the evaluation step students with this level can evaluate but there are still errors. In general, the results of this study are in line with the findings of Özgen et al. (2011) that the process of learning mathematics occurs through mental activities based on left, right and overall because in mathematical lateral thinking students with right brain and left brain dominance complement each other.

This study has answered the urgency of research related to mathematical lateral thinking barriers in terms of brain dominance and students'

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creativity level by using analytical techniques that tend to be new in mathematics education in Indonesia, namely Toulmin's argumentation analysis, however this research was limited to subjects with average level of mathematical ability and creativity.

Future research is still wide open, for example by using subjects who have creativity and high mathematical ability to find models of lateral thinking processes so that they will contribute as solutions to student learning barriers. In addition, this research was also limited to the context of geometry problems, open to further research through lateral thinking questions in the context of algebra, probability, or others. Further research opportunities are research on learning barriers in terms of didactic barriers, because this research is limited to ontogenic and epistemological barriers.

This study implied that in learning, teachers can divide students into groups of right-brain dominance and left-brain dominance. For right-brain dominant students, instruments are provided that emphasize concepts more and are strengthened by various contexts. Give a problem that allows for many answers or many ways. For students who are left-brained, more emphasis is placed on context and conceptual understanding associated with various contexts, so that contextual understanding and conceptual understanding are balanced.

## CONCLUSION AND SUGGESTION

The two main objectives of the research have been answered, that on the principle of "dominant idea" lateral thinking, LCS and RCS do not encounter obstacles. On the principle of finding different ways, LCS is limited by concepts and RCS is limited by context, while on the principle of flexibility, LCS experiences obstacles because the concept knowledge is weak and RCS experiences obstacles due to wrong concepts, so that LCS is unable to come up with new ideas because it thinks rigidly only in concepts and concepts. RCS has problems because it thinks rigidly based only on context.

Based on these findings, it is necessary to conduct further research with highly creative LCS and RCS subjects with high mathematical abilities to obtain an overview of lateral thinking processes that are useful in overcoming lateral thinking barriers experienced by LCS and RCS with average mathematical abilities.

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