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Design Development of Determinant Lines Materials and Angles on Math Learning for Junior High School

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***Abstract*—This research aims to develop new didactic designs on line and angles materials for junior high school students. The didactic design is designed by considering several things: the result of the analysis of the learning instrument test obstacle, learning trajectory, and the didactical situation theory. This didactic design consists of four meetings obtained through three formal stages conducted during the reseacrh. The first stage is prospective analysis was didactic situation analysis before learning in the form of hypothetical didactic design including ADP, the second metaper analysis was not the form of the design implementation stage, and the last was the retrospective analysis which was the analysis that correlates the prospective analysis with the metaproject analysis that was used to formulate the empirical didactic design. The research for preparing the didactic design began with a preliminary study which includes giving obstacle learning instrument tests, relevant thesis analysis, and a survey of students' mathematics textbooks. The didactic design was then implemented to 40 junior high school students of class VII. Based on the results of the research, didactic design that developed could be used as an alternative material teaching materials lines and angles to minimize student learning barriers.**

***Keywords*—Didactic design, line, angle, obstacle learning and learning trajectory**

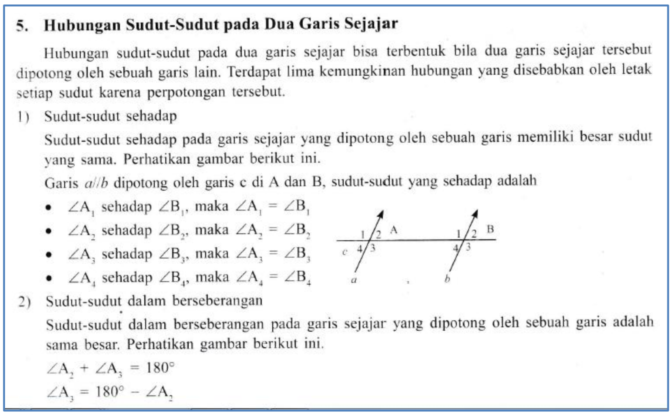
I. INTRODUCTION

Geometry is one of the most important branches of mathematics education, because the purpose of teaching geometry is to equip students with critical thinking skills, problem solving and better understanding of other materials in mathematics by making students have high-level geometric thinking skills [3] the 2006 curriculum for junior high school units, geometry has a charge of about 42% of the entire content of mathematical material viewed according to competency standards. This illustrates the importance of geometry taught in secondary school. In addition, by studying the geometry of students the opportunity to analyze and interpret their environment and equip students with tools that can be applied in other areas of mathematics [12], thus helping to train students' thinking skills.

Domain geometry in school math contains several concepts, one of them are the concept of lines and angles. This concept has even become an important basis for understanding other good mathematical concepts related to the material of geometry itself, such as rectangular and triangular matter, waking up, and other mathematical materials such as trigonometry and transformation. The importance of the concept of lines and angles in geometry was not in line with fact a field that shows the many barriers to learning experienced by students on the material.

The results showed some misconceptions done on the line material and angle, among others, the students did not understand the type of angle formed on two parallel lines cut by a line like the corners of the opposite and unilateral, wrong in calculating the number of angles in one side and wrong to determine the size of the angle in and out (unilateral and opposite), and students have difficulty drawing lines for [12]. Other studies seeking to extract information related to student misconduct on line and angles material were also done by [4]. According to the results of their research: 1) students only see the geometry drawings given without considering the geometry of the image; 2) even though the student knows the geometry of the image, the student fails to associate this trait with the other knowledge needed to find the solution of the problem; 3) the student is wrong in generalizing the nature that is only applicable to certain conditions; and 4) students do not fully understand the concept of parallelism on the subject of the angle. In proportion to these findings, [13] and [8] also found various learning barriers experienced by students regarding line and corner materials. The barriers are grouped into three types of learning barriers according to [5], namely epistemological obstacle, ontogenic obstacle, and dandidactical obstacle.

In addition to the findings above, the results of an analysis of the mathematical textbooks coraled by [16] concerning the matter of angular relationships always described by using direct definitions. Such learning only destroys the child on the ability to memorize the information so that the potential to generate obstacle learning. Along with this, [12] explains that one of the reasons students misconception in understanding the material about angular relationships is the inadequacy of students' understanding of formulas or definitions.



5. Hubungan Sudut-Sudut pada Dua Garis Sejajar

Hubungan sudut-sudut pada dua garis sejajar bisa terbentuk bila dua garis sejajar tersebut dipotong oleh sebuah garis lain. Terdapat lima kemungkinan hubungan yang disebabkan oleh letak setiap sudut karena perpotongan tersebut.

1) Sudut-sudut sehadap

Sudut-sudut sehadap pada garis sejajar yang dipotong oleh sebuah garis memiliki besar sudut yang sama. Perhatikan gambar berikut ini.

Garis *a*//*b* dipotong oleh garis c di A dan B, sudut-sudut yang sehadap adalah

- $\angle A_1$ sehadap $\angle B_1$, maka $\angle A_1 = \angle B_1$
- $\angle A_2$ sehadap $\angle B_2$, maka $\angle A_2 = \angle B_2$
- $\angle A_3$ sehadap $\angle B_3$, maka $\angle A_3 = \angle B_3$
- $\angle A_4$ sehadap $\angle B_4$, maka $\angle A_4 = \angle B_4$

2) Sudut-sudut dalam berseberangan

Sudut-sudut dalam berseberangan pada garis sejajar yang dipotong oleh sebuah garis adalah sama besar. Perhatikan gambar berikut ini.

$\angle A_2 + \angle A_3 = 180°$

$\angle A_3 = 180° - \angle A_2$

Fig. 1. The Relationship of Angles at Two Lines in Textbook

Considering the importance of line and angle materials and various misconceptions, obstacles or learning difficulties experienced by students in the concept, it was necessary to improve learning efforts. [1] suggests that systematic teaching materials could be used as an effort to overcome student difficulties in learning the material geometry. Improvement efforts offered in this research were the development of teaching materials, line materials and angles that were rich in context and student activities. As explained by [17] that active student involvement in a learning activity enables the child to gain an in-depth experience of the learned material that ultimately improves the child's understanding of the material.

Based on the above description, the main focus of this research were to obtain: 1) description of learning obstacle characteristic experienced by students on learning about line and angle materials. 2) Hypothetical didactic designs that were designed based on the results of obstacle learning analysis that students experience on learning about line and angle materials. 3) a description of the implementation of hypothetical didactic design based on student responses that appear on learning about line and angle materials. 4) Empirical didactic design that could be developed based on the results of implementation on the learning that has been implemented about the material line and angle.

II. RESEARCH METHODS

This reseacrh aims to design and construct a didactic design by considering the results of exploration and analysis of obstacle learning experienced by students in learning mathematics, especially on line and angle materials. Qualitative method was chosen as research method to be used. Qualitative research attempts to understand phenomena with a focus on the whole phenomenon [2], where the core phenomenon is ideas / ideas, or learning processes studied [6].

A. Research Design

This research focuses on the preparation of a didactic design so that the research design used refers to [18]. Formal steps in the design of this reseacrh were: 1) didactic situation analysis before learning in the form of hypothetical didactic design including ADP, 2) metaped analysis, and 3) Retrospective analysis in the form of an analysis that correlates between the result of hypothetical didactic situation analysis with the result of metapedadtive analysis [17].

B. Research Subject

The research form as implementation of didactic design hypothetical done in one of junior high schools in Makassar. The reseacrh early lasted from 11 January to 14 April 2016 with the subject of research were divided into two namely 1) students who were given learning obstacle instrument that was 58 junior high school students who have studied the material line and angle and 2) class VII students research subject of didactic design development that will get learning through didactic design with total sample of 40 students.

C. Research Data

The data collected in this research were 1) data about obstacle learning faced by students in learning the material line and angle, this data obtained from the preliminary study conducted and the previous research analysis, 2) the two data about the material line and angle seen from the perspective theoretical data obtained from theoretical analysis and the research of the repersonalization of the researcher; 3) the data of the results of the didactic design implementation, obtained through observation during the implementation of didactic design.

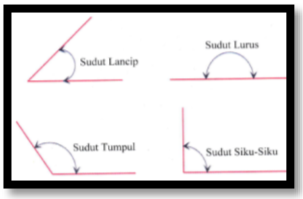
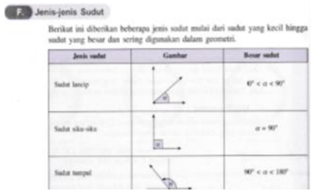
D. Data Collection and Techniques of Analysis

Triangulation was a data collection technique used in this research, which was a combination of interviews, observation, and documentation, including testing of student learning obstacle test instruments. The data collected is then analyzed. The process of data analysis done before entering the field, during the field, and after completion in the field.

TABLE 1. ANALYSIS OF OBSTACLE LEARNING BEFORE THE IMPLEMENTATION OF DIDACTIC DESIGN

Category of Learning Obstacle	Kinds of Learning Obstacle	Explanation
Epistemo-logical	Epistemological obstacle related to the concept of lines, rays, and segments	Looking at the variations in the students' answers to the epistemological barriers that researchers encountered in question 1 Could be divided into three parts. The first barriers to understanding the lines, rays, and segments, both students 'barriers to understanding symbols, and the students' understanding of both the terms and symbols of lines, rays, and segments (segments).
	Epistemological obstacle related to the concept of position of two lines.	According to the findings of the students' answers on question 4, it shows that most students did not understand about two lines intersecting, intersecting, and coinciding. Students were confused to determine the position of two lines on images that they rarely encounter in some problems (non-routine questions).

TABLE 1. ANALYSIS OF OBSTACLE LEARNING BEFORE THE IMPLEMENTATION OF DIDACTIC DESIGN

Category of Learning Obstacle	**Kinds of Learning Obstacle**	**Explanation**
	The epistemological obstacle was related to the concept of the relationship of the angles formed when two parallel lines are cut by a line.	• Students experience barriers in understanding the mutual relationship of two angles, about 50% of students misquoting 5 parts (a) and 24% choose not to answer. • Students experience obstacles in understanding the corners, 72% are wrong to determine the angle and 24% choose not to answer. • Students experience barriers in understanding unilateral and opposite angles. It was found that about 53% of students answered wrongly in determining unilateral angle and 66% wrong in determining the opposite angle. One of the factors that causes this is because students tend to only memorize the names of these angles as the reason that the students expressed that "we used to memorize but because it has been so long we forgot again".
	Students find it difficult or even incapable of communicating an answer that was not a number seen from the student's answer to the 5-part (a) and (b) questions.	Seeing the results of the answers and reference books of students, the researchers concluded that students consider mathematics was a lesson counting with answers to questions because it was always a number or symbol, the assumption that they unknowingly have led them to tend to answer math problems using numbers. It was characterized by many students who chose not to answer the reason, answered the reason by operating the number (not with the sentence), and ambiguous in writing the sentence for that reason
Dictation	Students do not understand some of the symbols that were often used on the material lines and angles such as angular symbols, lines, parallel lines and others.	• Symbols are a language or communication tool in mathematics that is solid in content and universal, resulting from an agreement, and needs to be introduced to students [9]. Therefore, students' understanding of the symbols of a line, rays and segments (segments) must be a matter of concern. But 78% of students mistakenly symbolize the problem 1. It is found that while understanding the concept, students feel confused to symbolize the impact on symbols according to their own language. In addition the researchers found that some textbooks of mathematics lessons that teachers often use in learning does not touch on the concept of lines, rays, segments and symbols.
		• Didactic barriers in determining angle types. There were 57% and 81% of students answered incorrectly in determining the angle type on the 2-part (a) and (b) problem. They are accustomed to just looking at the position regardless of the angle region symbol in question and not checking the existence of the right symbol on the image. One of the reasons is that most students are accustomed to the right angle of the picture presented in the same position as in the following two books:  

B. Development of Dictitious Design

The development of didactic design in this research, in addition to considering the results of the preliminary analysis, was also adapted to the learning trajectory (LT) as illustrated in the following chart below.

Fig. 2. Learning Trajectory

Learning trajectory that was essentially the same as learning progressions emerged first in the context of science education [7]. LT was compiled based on curriculum demands without compromising the student learning obstacle test results. Unlike the LT teaching materials in general that directly presents the concept of the angle, LT in this research begins with the concept of lines, rays, and segments and then leads to the symbol of the three. This was based on the consideration of the learning obstacles findings of students in some obstacle epistemological problems both in terms of understanding the concept of lines, rays, and segments and symbols so that the necessary discussion in the beginning before learning the next concepts.

Each of the line and angles material concepts contained in the above LT would be structured in several didactic situations in each lesson design as described in the table below.

TABLE II Hypothetic Didactic Design Arrangement

Lesson Design	**Aims**	**Situation**
1	*Lesson Design* I was designed for a one-off meeting that contains two learning objectives: 1) explaining the position of two lines and 2) explaining the different angle types.	Situation 1 aims to distinguish the lines, rays, and segments (segments) and their symbols
		Situation 2 aims to explain the position of the two lines (parallel, coincident, and intersect)
		Situation 3 aims to see students' understanding of angular concepts and angle types
		Situation 4 aims to explain about the angles that my mutual interest (kompomp)
		Situation 5 describes the angles that are mutual
		Situation 6 aims to explain the opposing angle
		Situation 7 aims to check students' responsiveness in understanding the previous situation, the obstacles experienced, and to see how far students can relate some information to the problem to determine the settlement.
2	Lesson Design 2 was designed for one meeting that contains two learning objectives: 1) finding angular properties if two parallel lines are cut off by the third line (another line) and 2) using angular and line properties to solve the problem.	Situation 1 aims to find the properties of parallel lines arranged in each of the three activities
		Situation 2 aims to explain guiding the student to understand the material about the term and the nature of the angle formed when two parallel lines are cut off another line
		Situations 3 and 4 aim to see students' understanding after studying the previous situation and to measure the extent to which students can connect the information presented to the problem to determine the solution to the situation.
3	Lesson Design 3 was designed for a one-off meeting aimed at training students' comprehension, reasoning, connections and analysis skills by painting a certain angle using a ruler and run.	Situation 1 aims to understand how to divide the angle into two equal parts by using ruler and run
		Situation 2 aims to understand how to paint angles 90o, 45o, 60o, and 30 o
		Situation 3 aims to see students' understanding in painting a certain angle using the knowledge gained in previous situations as well as training some student competencies.

Some situations in the lesson design would guide students to understand the concepts in the line and angle material through the activities or activities in which they construct their own knowledge, then other situations were designed to see students' achievement in understanding the material learned earlier. Suppose the first situation on lesson design 1 as showed in the picture below.

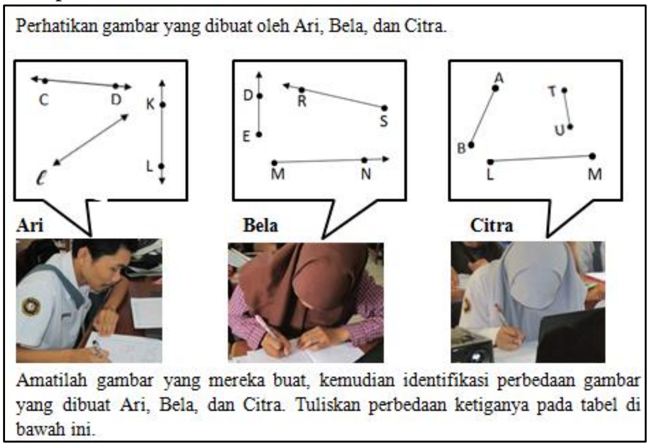


Fig. 3. Situation on Lesson

The situation was aimed at guiding students to understand the c\oncept of lines, rays, and segments along with their symbols. The situation was the way with the contrast theory of Bruner (Suherman et al, 2003, p38) that a mathematical concept is more easily understood when contrasted with other concepts. After understanding the concept of lines, rays, and segments, in situation 1, the concept of position of two lines in situation 2, the concept of angle types in situation 3, the next situation was situation 4, 5, and 6 in lesson design 1 students would be delivered to understand the concept of relationship between angles through activities like the image below, to construct his own knowledge. This situation was in line with the theory of meaningful learning by Ausubel.

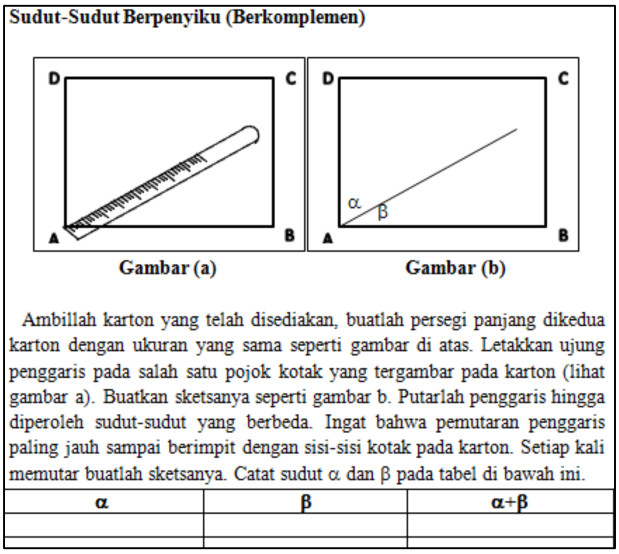


Fig. 4. Complement Angel

Furthermore, lesson design 2 was designed to minimize the epistemological constraints associated with the concept of angular relationships formed when two lines intersect another line and based on the view of Bruner's connectivity theory. In the initial situation students would be presented with situations that lead them to understand the properties of parallel lines that are divided into three activities. After understanding the nature of parallel lines, in the new situation 2 then the students learn the term and the angular properties that were formed if two parallel lines were cut off another line. Situation 2 began by showed students to contextual images of parallel lines that were cut off other lines such as the following.

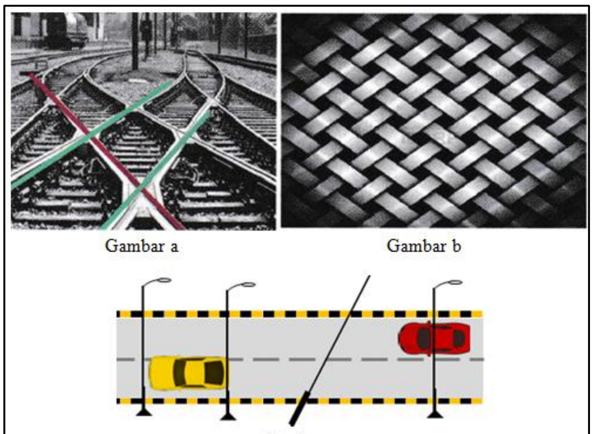


Fig. 5. Ilustration of Cross Lines

Based on the illustration, students were asked to sketch their own two parallel lines and then cut another line. The situations designed were in line with the theory of constructivism learning which views that each individual constitutes / builds most of what they learn and understand [15]. The expected response appears in this situation was the students drawing like the picture below, which then becomes the beginning to recognize and understand the terms and properties of the angle formed from the image.

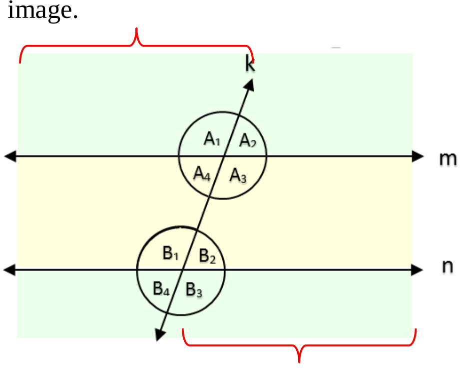


Fig. 6. Term and Properties of The Angel

Finally situations 3 and 4 aim to check students' understanding of the material presented in the overall situation that students have learned before. The purpose and form of the problem in situation 4 was similar to situation 3 but more developed so that the level was more complex than the situation 3. Situations 3 and 4 showed in the figure below.

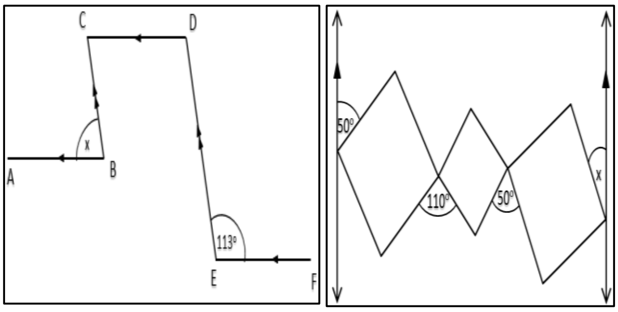


Fig. 7. Developement of angel's term and properties

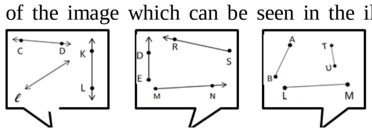
C. Implementation of Dictitious Design

The implementation process was generally the same in every implementation of a didactic situation. Begin by displaying the situation as the starting point of learning, then discussion among students, and the last student will write a conclusion or determine the settlement of the given problem. In the course of the process, teachers pay attention to the responses given by the students and give action according to anticipation that has been designed previously. If the student is having trouble the teacher will intervene in the form of gradual relief or called scaffolding term in Vygotsky Learning Theory [10]. The implementation of the three lesson designs suggests that predicted student responses occur despite some other unpredictable responses in some situations as well. It is like a student's response to the first situation for lesson design 1 in which students see the arrows as "triangle" shapes and dots called "round". Such a response can be considered for design revision after implementation to produce a better didactic design than before.

D. Design of Revised Dictition

Based on the analysis of each situation in the design of Lesson Design 1 to 3 and looking at its relevance to the student response during the implementation or in [18] theory known as retrospective analysis, there were several recommendations to revise the didactic design. The first revision was on Lesson Design 1 which would be divided into two meetings. The two additional situations at the aforementioned meeting and some other revisions were illustrated in the following TABLE III.

TABEL III. DESIGN OF REVISED DICTITION

Design of Diction	Explanation
Situation I for Lesson Design 1	The revision made in this situation lies in the improvement of the image which can be seen in the illustration below.  The revision of the drawing was intended to clarify the arrows to anticipate the response obtained during implementation.

TABEL III. DESIGN OF REVISED DICTITION

Situation 3 for *Lesson Design 1*	The improvements made to situation 3 are grouped into two parts: in terms of images and sentences of the questions in the situation. The previous image looks like a three-dimensional wake is transformed into two-dimensional images. The revision is intended to make it easier for students to observe the intended angle so that the time required to implement can be more efficient.
Situation 4 and 5 for *Lesson Design 1*	Combining situations 4 and 5 in an activity so that it could be one of the efforts in managing the duration of learning to gain time to implement the last situation in the classroom. Merging the two situations causes changes to the illustrations and sentences used in the design.
Situation 1 and 2 for *Lesson Design 2*	A revision made to situation 1 is to add some instructions to the student's LKS. This is done because it sees the student's response at the time of implementation, which is mostly difficult to guess the idea of inferring parallelism. Revisions by adding instructions are intended to be guidance of students in finding ideas for parallel lines based on the activities they are working on the LKS. Situation 2 was revised by adding pictures. Revision is done considering that at the time of implementation not all situations can be implemented in the class so that to make efficient the time drawing students should have their own instruction presented directly.

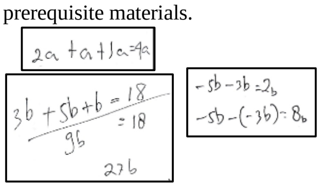
E. Analysis of Learning Obstacle after Implementation of Dictitious Design

The didactic design was designed one of them by considering the result of obstacle learning analysis in order to minimize the obstacle experienced by the students. The author describes the learning obstacle at the beginning of this chapter by exploring several aspects. Not only the right or wrong consideration of students, but rather to how students process the solution of the problem and find the location of obstacles experienced in solving the problem. The obstacle learning test instrument provided after the implementation of the design is implemented will also be analyzed as well as the previous obstacle learning analysis. This can indicate the extent to which didactic designs have an effect to minimize the constraints experienced by students.

TABLE IV. ANALYSIS OF LEARNING OBSTACLE AFTER IMPLEMENTATION OF DICTITIOUS DESIGN

<table>
<tr><th>Category of Learning Obstacle</th><th>Kinds of Learning Obstacle</th><th>Explanation</th></tr>
<tr><td>Epistemological</td><td>Obstacles epistemologi (epistemological obstacle) related to the concept of lines, rays, and segments (segment)</td><td>
The findings were categorized into two parts: 1) related to the writing of symbols in answering the number 1 questions as listed in the first table and 2) regarding the students' understanding of the concept of lines, rays, segments (segments) as written in the second table. The first table explains that there is a correct increase in the percentage of students and a decrease in the percentage of students who are either wrong or not answering questions.
<table>
<tr><th>Respondent</th><th>True</th><th>False</th><th>Responsible</th></tr>
<tr><td rowspan="3">Class VII Following the Obsession Learning Instrument Test before Implementation</td><td>8,97 %</td><td>70,69 %</td><td>10,34 %</td></tr>
<tr><td>1,72 %</td><td>86,72 %</td><td>12,07 %</td></tr>
<tr><td>10,34 %</td><td>72,41 %</td><td>17,24 %</td></tr>
<tr><td rowspan="3">Class VII Following the Obsession Learning Instrument Test after Implementation</td><td>52,63 %</td><td>44,74 %</td><td>2,63 %</td></tr>
<tr><td>50,00 %</td><td>42,11 %</td><td>7,89 %</td></tr>
<tr><td>47,37 %</td><td>42,11 %</td><td>10,53 %</td></tr>
</table>
<table>
<tr><th>Respondent</th><th>True</th><th>False</th><th>Responsible</th></tr>
<tr><td>Class VII Following the Obsession Learning Instrument Test before Implementation</td><td>15,52 %</td><td>77,59 %</td><td>6,9 %</td></tr>
<tr><td>Class VII Following the Obsession Learning Instrument Test after Implementation</td><td>55,26 %</td><td>44,74 %</td><td>0 %</td></tr>
</table>
In addition, the student's response to question 3 was also related to the students' ability to understand the lines and segments (segments). The percentage of student responses to question 3 was listed in the following table.
</td></tr>
</table>

TABLE IV. ANALYSIS OF LEARNING OBSTACLE AFTER IMPLEMENTATION OF DICTITIOUS DESIGN

<table>
<tr><th>Category of Learning Obstacle</th><th>Kinds of Learning Obstacle</th><th>Explanation</th></tr>
<tr><td rowspan="3"></td><td></td><td>
<table>
<tr><th>Respondent</th><th>True</th><th>False</th><th>Responsible</th></tr>
<tr><td>Class VII Following the Obsession Learning Instrument Test before Implementation</td><td>24,14 %</td><td>75,86 %</td><td>0 %</td></tr>
<tr><td>Class VII Following the Obsession Learning Instrument Test after Implementation</td><td>68,42 %</td><td>31,58 %</td><td>0 %</td></tr>
</table>
The table above indicates that most students could understand the terms of the line and segman (segment) so that they could answer the 3 questions correctly. However, there were still students who have not understood the meaning of lines, rays, and segments (segments) and the third symbol so that it could be taken into consideration in undertaking the didactic design revision.</td></tr>
<tr><td>Epistemological obstacles related to the concept of the position of two lines.</td><td>In general, the obstacles students experience in solving the problem about the position of two lines were similarity, the students who often felt confused in putting the position of the line if given a different image and rarely they found before or it called non-routine as problem percentage of student error in resolving question 4 below.
<table>
<tr><th>Respondent</th><th>True</th><th>False</th><th>responsible</th></tr>
<tr><td rowspan="4">Class VII Following the Obsession Learning Instrument Test before Implementation</td><td>81,03 %</td><td>17,24 %</td><td>1,72 %</td></tr>
<tr><td>29,31 %</td><td>50,00 %</td><td>20,69 %</td></tr>
<tr><td>1,72 %</td><td>75,86 %</td><td>22,41 %</td></tr>
<tr><td>1,72 %</td><td>75,85 %</td><td>22,41%</td></tr>
<tr><td rowspan="4">Class VII Following the Obsession Learning Instrument Test after Implementation</td><td>84,21 %</td><td>15,79 %</td><td>0 %</td></tr>
<tr><td>44,74 %</td><td>55,26 %</td><td>0 %</td></tr>
<tr><td>34,21 %</td><td>60,53 %</td><td>5,26 %</td></tr>
<tr><td>18,42 %</td><td>71,05 %</td><td>10,53 %</td></tr>
</table>
Interview conducted by the authors found that one of the barriers experienced by students in working on problem 4 was the limited ability of spatial. The ability to manipulate images mentally, rotate, or reverse them, as suggested by McGee [11].</td></tr>
<tr><td>The epistemological obstacle was related to the concept of the relationship of the angles formed when two parallel lines are cut by a line.</td><td>The epistemological constraints associated with the concept of angular relationships formed when two parallel lines are cut off by a line, it can be seen from the student's answer to 5 which was illustrated in the following table.
<table>
<tr><th>Respondent</th><th>True</th><th>False</th><th>Responsible</th></tr>
<tr><td rowspan="5">Class VII Following the Obsession Learning Instrument Test before Implementation</td><td>25,86 %</td><td>50,00 %</td><td>24,14 %</td></tr>
<tr><td>31,03 %</td><td>34,48 %</td><td>34,48 %</td></tr>
<tr><td>20,69 %</td><td>44,83 %</td><td>34,48 %</td></tr>
<tr><td>27,59 %</td><td>53,45 %</td><td>18,97 %</td></tr>
<tr><td>15,52 %</td><td>65,52 %</td><td>18,97 %</td></tr>
<tr><td rowspan="5">Class VII Following the Obsession Learning Instrument Test after Implementation</td><td>57,89 %</td><td>39,47 %</td><td>2,63 %</td></tr>
<tr><td>55,26 %</td><td>42,11 %</td><td>2,63 %</td></tr>
<tr><td>60,53 %</td><td>36,84 %</td><td>2,63 %</td></tr>
<tr><td>42,11 %</td><td>55,26 %</td><td>2,63 %</td></tr>
<tr><td>34,21 %</td><td>60,53 %</td><td>5,26 %</td></tr>
</table></td></tr>
<tr><td>Ontogenic</td><td>Student problem in prerequisite material. The prerequisite material was integer operation and the understanding about linear equation materials either one variable or two variable.</td><td>The ontogenic constraints found in the learning obstacle analysis after implementation were obtained from the results of the student interviews on the answers given for questions 6 and 7 where the problem students were in prerequisite materials.


[14] incorporate the criteria of the calculation process into the category of technical errors and for prerequisite material errors are included in the originating error criteria of misconceptions of previously learned material.</td></tr>
</table>

TABLE IV. ANALYSIS OF LEARNING OBSTACLE AFTER IMPLEMENTATION OF DICTITIOUS DESIGN

<table>
<tr>
<td>Dictation</td>
<td>Students answer more questions 4 without writing a line symbol that has been studied before students understand the content of the question.</td>
<td>The dictition barriers found in the student's answer to item 4 with the percentage of errors listed in the Table below.
<table>
<tr><th>Respondent</th><th>True</th><th>False</th><th>responsible</th></tr>
<tr><td>Class VII Following the Obsession Learning Instrument Test before Implementation</td><td>8,62 %</td><td>91,38 %</td><td>0 %</td></tr>
<tr><td>Class VII Following the Obsession Learning Instrument Test after Implementation</td><td>26,32 %</td><td>68,42 %</td><td>5,26 %</td></tr>
</table>
This was due to the teacher's lack of emphasis on providing a symbol for a line or segment and students become accustomed to writing only in two capital letters.</td>
</tr>
</table>

III. CONCLUSIONS AND SUGGESTIONS

A. Conclusion

Based on the results of the research and discussion obtained some conclusions as follows:

1. Learning obstacles identified in didactic design research of line and angle materials include ontogenic obstacles, didactical obstacles, and epistemological obstacles. The three types of obstacle learning were found through the analysis of students' answers class VII Junior High School on the learning instrument test of line and angle materials, student interview analysis, and mathematics textbooks A, B, C and D.
2. Didactic design was designed and developed based on the results of preliminary analysis and didactic situation theory and adapted to learning trajectory to overcome or minimize the constraints experienced by students in understanding the material of lines and angles. The didactic design consists of didactic design to understand the position of the two lines and the types of angles, the didactic design to find and understand the terms with angular properties formed if two parallel lines were cut off the other, and the didactic design to practice the ability to paint the angle.
3. Student responses that appear at the time of the implementation of didactic design were largely recorded in the predicted response designed. Nevertheless, there were several predictive responses that did not appear as well as any response beyond the designed prediction. For responses beyond prediction, teachers could cope with some action taken during implementation and become recommendations of empirical didactic design revisions.
4. The empiric didactic design of line and angle materials was developed based on the results of the design implementation analysis. In empiric didactic designs some didactic situations were changed either in terms of illustrations or images as well as sentence context (instructions or questions).

B. Suggestions

Suggestions from research conducted as input for line, angle research and similar research, among others are explained as follows:

1. Should be done direct observation on the class that will be used before the implementation of didactic design done, for example by participating in learning while teaching by the teacher so that it can observe the learning path that teachers usually do in the classroom and know the condition and characteristics of students.
2. Perform a deep repersonalization and recontextualization in order to develop a better didactic design as both are strengths in didactic design research.
3. The development of didactic design of line and angle materials in this study can be implemented or developed again by taking into account some of the obstacles that are still experienced by students after the implementation of the design.
4. Need to improve skills in 1) time management, 2) choosing the right way of teaching (model, strategy, or learning approach) in each material so as to facilitate the students to achieve the learning objectives; and 3) organizing the class with a sufficient number of students.

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