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Implementation of virtual manipulative using problem-based learning on topic algebra for seventh grade student

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Abstract. The aim of this study to find out the learning design of virtual manipulative using Problem Based Learning (PBL) on seventh grade student in algebra concept. This study was conducted at Junior High School Santo Aloysius Turi from October to February 2019. The research subjects were students of class VIIB (pilot experiment) and VIIA (teaching experiment) in 2018/2019. The type of research used in this study is design research, where researchers design Hypothetical Learning Trajectory (HLT) to teach algebraic operating using virtual manipulative with PBL models. The research stages are preliminary design, experimental design which includes a pilot experiment and teaching experiments, and retrospective analysis. Data collection methods used are documentation, field notes, written tests, and unstructured interviews. Technical data analysis is used according to Miles and Huberman methods, including data reduction, data display, and verification or conclusion. The results showed that the design of learning with virtual manipulative using the Problem Based Learning (PBL) model on the topic of algebraic in class VII of Junior High School Santo Aloysius Turi is as follows: at the point of the preliminary test it can be observed that students still have difficulty in connecting problems into algebraic forms, using the concept of associative and distributive properties to simplify algebraic forms according to their operations in addition, subtraction and multiplication of algebraic forms. Using virtual manipulative with the PBL model can help students to construct their knowledge in order to understand associative and distributive properties used to simplify algebraic forms.

1. Introduction

Teachers are required to be able to keep up with the times and be increasingly creative and innovative in building a conducive learning atmosphere. One way teachers can do this is to use learning methods that trigger students' creativity and thinking in developing mathematics. The abstract mathematical concepts that have been applied so far can be applied in interesting and innovative way. Patricia S. Moyer, Johnna J. Bolyard and Mark A. Spikell [2] provide definitions of virtual manipulative as an interactive, technology enabled visual representation of a dynamic mathematical object, including all of the programmable features that allow it to be manipulated, that presents opportunities for constructing mathematical knowledge. According to Paivio [7] virtual manipulatives can develop students' visualization skills by connecting words, pictures, and symbols simultaneously. This simultaneous presentation can assist students in developing a solid understanding of mathematical concepts.

The use of models and methods in learning is very influential in the achievement of a learning goal. According to Afandi [1] the learning model is a systematic procedure or pattern that is used as a guideline to achieve learning goals in which there are strategies, techniques, methods, materials, media



and learning assessment tools. While the learning method is the way or stage used in the interaction between students and educators to achieve the learning objectives that have been set in accordance with the material and mechanism of the learning method. One example of a learning model is the problem-based learning model. One thing that differentiates the problem-based learning model different from the other learning models is that the role of the teacher is to offer various problems, provide questions, and facilitate investigation and dialogue. The teacher gives the opportunity for students to set the topic of the problem to be discussed, even though the teacher has actually set the topic of the problem that should be discussed. The most important thing is that the teacher provides a scaffolding or supporting framework that can improve the ability of the investigator and students' intelligence in thinking. The learning process is directed so that students are able to solve problems systematically and logically. This learning model can occur if the teacher can create an open and honest classroom environment, because the class itself is a place for exchanging students' ideas in response to various problems. According to Arends [1] problem-based teaching is a learning approach where students work on authentic problems with the intention of developing their own knowledge, developing inquiry and higher-level thinking skills, developing independence, and self-confidence. The problem-based learning (PBL) approach is a learning concept that helps teachers create a learning environment that starts with important and relevant problems for students and allow students to gain a more realistic learning experience.

According to Barab & Squire [10] design research is a series of approaches with the aim of producing new theories, artifacts and practical models that explain and potentially impact learning with naturalistic settings. Furthermore, according to Plomp [10] design research is a systematic study of designing, developing and evaluating educational interventions (such as programs, strategies and learning materials, products and systems) as solutions to solving complex problems in educational practice, which also aim to advance our knowledge about the characteristics of these interventions and their design and development processes.

Based on the results of interviews with mathematics teachers at Junior High School Santo Aloysius Turi, it was found that the learning model used in mathematics learning varied. However, the teacher admitted that he still relied on conventional learning approaches where learning is often done using peer tutors, lecture methods with power points, and training or drill. The availability of computer facilities at the school is adequate, this is indicated by the existence of a Lab room. Multimedia and LCD are available in each class, but their use is still very limited by subject teachers. Regarding the location of the study, the researcher found that both design and virtual manipulative research with the PBL model had not been applied in the school. The teacher has not designed a learning process that looks deeply into the possibilities of student answers and uses the PBL model or virtual manipulative learning. Furthermore, on the preliminary test the researchers gave on February 13, 2018 in the VIIC class at the Junior High School Santo Aloysius Turi, amounting to 20 students, the researchers had the opportunity to take 3×40 minutes to give a test on algebraic surgery. The test aims to get an overview of the knowledge of students who have been taught algebraic surgery. This period of time was selected to ensure that during 1 hour of study researchers were able to get to know students and review an outline of algebraic topics before proceeding with the completion of the test questions for 2×40 minutes. The learning process enables the researcher to obtain information, namely: only a few students still remember material from algebra, some students do not have the initiative to express their opinions, seemingly waiting for their friends to express their opinions, and other students often waited when appointed to express their opinions. In addition, student learning independence is also lacking. Students often wait for an explanation from the teacher to explain a concept or solve the problem. Some students ask their friends about solving problems before trying to work on their own. Students should have initiatives to study material and not depend on others. This lack of student activity causes students to lack focus in learning. Students are less able to connect a component of the problem with other components to solve the problem. During this preliminary test, two problems were given to students. After giving these two problems, the researcher provided the opportunity for students to solve these problems individually. The results of student answers and interviews obtained

several different pieces of information, namely: there are no students who tried to use algebra in solving the problem. Students who did not get the results were limited in determining the value of the variable, there were students who incorrectly multiplied constants and algebraic forms such as $2(3x + 8) = 6x + 8$, there were students who did not determine the value of the variable but directly determined the length and width, there are those who do not write known, asked or answered even though they were warned before starting the problem solving process by researchers, there were students who were wrong when simplifying algebraic forms such as $10x + 24 = 34x$ and $6x + 16 = 22x$. Based on the results of interviews with these students, during the first problem students experienced difficulty in connecting the problem with an algebraic form so they immediately resorted to counting in order to determine the answer. Whereas in the second problem, most students can associate the algebraic concept with circumference of the rectangle but experience difficulties when adding or multiplying algebraic forms.

According to Darma's [5] research, there is difference in mathematical problem-solving ability between the students facilitated with problem-based learning model and the conventional learning model. This is seen in the results of his research, which show that students in the class facilitated with PBL and authentic assessment discuss intensively in groups, orally ask each other questions, answer, criticize, correct, and clarify each mathematical concept or argument that appears in the discussion. In such discussion, students also develop their abilities to create, refine, and explore conjectures so as to establish their understanding of the mathematical concepts they are learning or the mathematical problems they are solving. For the students in class facilitated with conventional learning model and authentic assessment, the learning process tends to be centered on the lecturer. In the learning program plan, the lecturer does not pay attention to the prior knowledge of the students. The learning process takes place in one direction, the role of the lecturer is no longer as a good motivator, facilitator, or mediator; however, the lecture holds the authority of what is taught. In learning activities, the lecturer tends to use a few lecture methods followed by discussion. The lecturer tries to move or transmit his/her knowledge to the students. This condition tends to make students passively receive lessons. Furthermore, According to Hasanah [9] in his research on the application of VMME (virtual manipulative mathematics in education) shows that through virtual manipulative can increase student motivation in mathematics learning, namely: (1) liking math teachers increased from 9 students (21.95%) to 27 students (69.23%), (2) paying attention to the teacher's explanation in the learning process increased from 10 students (24.39%) to 35 students (89.74%), (3) asking questions that were not understood increased from 10 students (4.63%) to 29 students (74.36%), (4) enthusiastic to conduct timely assessments increased from 8 students (19.51%) to 35 students (89.74%). Furthermore, Irawati [8] in her research emphasized the use of computers as a medium in learning can increase student motivation. The results of his research showed that some students were helped in understanding the concept of solving linear equations with one variable. This can be observed through questions relating to the completion of one variable linear equation that can be solved by students. As well as in this study, it is known that students are happier and more interested in learning by using virtual teaching aids, such as "Algebra Build the Equations Model". Next, in their article, Durmus & Karakirik suggest that virtual manipulative algebra tiles give users the opportunity to investigate problems on the site and connect them with algebraic concepts.[6]

Ideas emerge from collaboration between technology and learning in the classroom, in this case mathematics learning. Given the increasingly widespread use of the internet throughout the world, many scientists have dedicated their ideas to visualizing abstract mathematics into technology. This certainly has an impact on the teacher, as the teacher is able to apply it. The notion that mathematics is difficult and boring can be changed using virtual tools. The fact is that mathematical teaching aids that have been developed in schools and universities in order to develop a creative and innovative learning process that has led to the idea of creating these mathematical teaching aids in virtual forms so that they are easily accessible to various communities in order to understand mathematics lessons that are difficult.

Based on this fact, the researcher has tried to solve this problem to help improve students' understanding and ability to construct algebraic concepts through the use of virtual manipulative with the PBL approach. The research question in this research was, "how can the learning process using virtual manipulative with Problem Based Learning (PBL) model on topic algebraic be applied?"

2. Research Methods

The type of research used in this study is design research. According to Plomp [3], design research includes a systematic learning starting from designing, developing and evaluating all interventions related to education, such as programs, learning processes, learning environments, teaching materials, learning products, and learning systems. There are two important aspects related to design research, namely the Hypothetical Learning Trajectory (HLT) and Local Instruction Theory (LIT).

The research subjects in this study were students of class VIIB (first research class) and class VIIA (second research class) Junior High School Santo Aloysius Turi Sleman Yogyakarta 2018/2019. The object of research in this study is the learning trajectory for learning algebraic operating material using virtual manipulatives with PBL models. The research data collection was conducted from October 2018 until February 2019. The timing of the data collection was adjusted to the timing of the subjects. At the stage of the teaching experiment, the research subject consisted of one class. Furthermore, at the stage of the pilot trial, the research subjects consisted of one different class. The location of this study took place at Junior High School Santo Aloysius Turi, Donokerto, Turi, Sleman Regency, Yogyakarta.

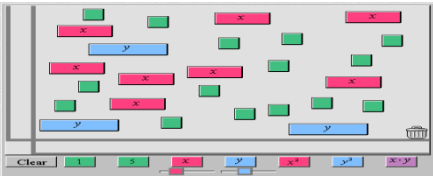

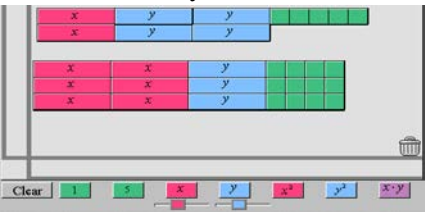


Data collection techniques carried out in this study were observation, interviews, written tests, documentation and literature. The data collection instrument is the interview guide sheet and HLT. The data analysis in this study used a qualitative approach which was carried out through the arrangement of data logically and systematically, and data analysis was carried out from the beginning the researcher entered the research site until the end of the study. According to Miles and Huberman [4] activities in qualitative data analysis are carried out interactively and take place continuously until complete, so the data is saturated. The steps of data analysis in this study are data reduction, data display, and verification or conclusion.

3. Result & Discussion

3.1. Trial Research Design

The researcher designed learning about virtual manipulative problems related to algebraic operations using the PBL model. There were 6 problems designed by the researcher for study, which were utilized 2 meetings. The three problems were used for learning at the first meeting and three problems were used for learning the second meeting. The purpose of holding two class meetings was to find out the learning trajectory in learning algebraic material with a virtual manipulative using the PBL model. The following table shows the problems that are given to the class VII_B:

Table 1. The problems given to class VII_B as the trial class

First meeting	Second meeting
<p>1. </p> <p>Using the information above, how do you simplify the forms above? Make conclusions from the results of your work!</p>	<p>1. </p> <p>Show the multiplication of algebraic forms by filling in the rectangle. What can you conclude from your work?</p>
<p>2. </p> <p>Determine the addition and subtraction results of the first and second order in the virtual image above! State the results of your answers in algebraic form!</p>	<p>2. </p> <p>Based on the picture above, determine the factors of the arrangement of the tiles!</p>
<p>3. Simplify the following algebraic forms:</p> <p>a. $(5x^2 + 4x + 8) + (x^2 + 6x + y)$</p> <p>b. $(2y^2 + 5y + 3) - (3y^2 + 3x + 8)$</p>	<p>3. </p> <p>Squared the following statement using algebra tile: $(x + 2)^2$; $(2x + y)^2$! How do you solve this problem?</p>

The implementation of HLT trials took place in class VII_B for 2 meetings using virtual manipulative software related to algebraic operations with PBL models. The number of students in VII_B class is 26 students. Therefore, researchers divided students into 4 discussion groups heterogeneously and each group consisted of 6 to 7 students. These problems are taken and developed by researchers from the website National Library of Virtual (<http://nvlm.usu.edu/>). According with the table above, in the first meeting, each group was given an activity to simplify the algebraic form contained in the virtual manipulative site. It is intended that students creatively find ways to understand the concept of associative and distributive nature in the operation of addition and subtraction of algebraic forms. While at the second meeting, each group was given an activity to determine the results of the multiplication of the two algebraic tribes by filling in the long rectangles contained on the virtual manipulative site. It is intended that students creatively find ways to understand the concept of associative and distributive nature in the multiplication of algebraic forms. The following is a table for implementing HLT trials in class VII_B:

Table 2. Learning Activities at the First and Second Meetings in the Trial class

Class/ School: VII_B / Junior High School Santo Aloysius Turi Yogyakarta			
Learning	Date and Time	Time Allocation	The Number of Student
First meeting	Monday, 22 October 2018	3 × 40minutes (08.40-10.45 WIB)	24 students
Second meeting	Monday, 29 October 2018	3 × 40minutes (08.40-10.45 WIB)	25 students

Analysis of the learning process that occurs in the trial class has been completed in order to counter the deficiencies contained in the HLT that has been designed. The following is one analysis of the results of group discussions that were found in the second meeting in the trial class:

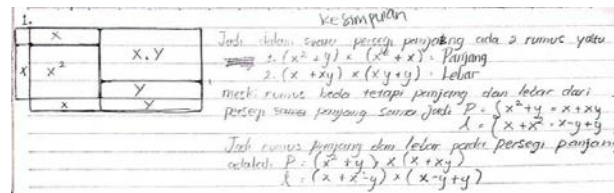


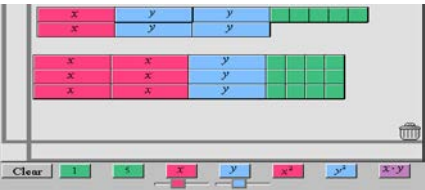




Figure 1. One of the results of group discussions in the trial class

Based on the results of the group discussion on the problem, it was seen that when compiling the boxes, the groups did not make the appropriate arrangements to determine the results of multiplying the two forms of the algebra. This resulted in group conclusions that were not in accordance with the desired results. One group concluded that the length of the rectangle is expressed as $x^2 + y = x + xy$ and the width is $x + x^2 = xy + y$. Then the same group concluded that the result of multiplying the two algebraic forms into a formula that states the length and width of a rectangle is $p = (x^2 + y) \times (x + xy)$ and $l = (x + xy) \times (xy + y)$. Based on the description of the results of the group discussion above, the group was able to state the area formula of the rectangle but when applied to the algebraic form the group was still not precise and the group was unable to connect the virtual form to the length and width of the rectangle. The group was not able to classify the arrangement of squares according to the length and width of the rectangle and could not classify the results of the algebraic multiplication with the area of the rectangle so that the results of the problem solving are not correct. This answer was not found in the initial HLT design compiled by the researcher, so the researcher added the possibility of this answer to the HLT design.

After testing the HLT results of the preliminary design in the VIIB class, the researcher conducted a revised HLT. The revised HLT results will be used to conduct learning in the VIIA class as the second research class. The changes made by the researcher from the learning process to the learning outcomes are as follows: (1) the researcher has added questions and information contained in the problem given to make it easier for students to understand the problem, namely connecting algebraic forms into virtual forms and vice versa. (2) The researcher has added the possibility of students' answers in the problem solving process, namely in the steps in the problems of the first and second meetings, namely changing the arrangement of virtual boxes into algebraic forms according to their operations and conclusions on the results of the answers given in accordance with the questions the researcher added in the revision. In addition, the possibility of student's incorrect answers relating to expressing the arrangement of virtual boxes into algebraic forms, as well as errors in simplifying the algebraic form that the researcher found during the learning process that were not included in the original HLT design were added according to what the researcher found in the group's answer results in the test class trial. The following is a table showing the problems given to the research class as a result of revision:

Table 3. The problems given to class VII_A as the research class

First meeting	Second meeting
<p>1. </p> <p>Using the information above, how do you simplify the forms above? Make conclusions from the results of your work!</p>	<p>1. </p> <p>Arrange in a rectangle on the virtual manipulative above to show the multiplication results $(x + 1)(x + y)$! What is the result of the multiplication of the two algebraic tribes? Explain the results of your work!</p>
<p>2. </p> <p>Determine the addition and subtraction results of the first and second order in the virtual image above! State the results of your answers in algebraic form!</p>	<p>2. </p> <p>Here is a virtual form of the algebraic tribe $2x^2 + 4xy + 3x + 4y$. Determine the two algebraic terms that are factors in the algebraic form by filling in the vertical and horizontal rows! What kind of relationship can you conclude?</p>
<p>3. Using virtual manipulative, determine the results of the subtraction and addition of the following algebraic terms:</p> <ol style="list-style-type: none"> $(5x^2 + 4x + 8) + (x^2 + 6x + y)$ $(2y^2 + 5y + 3) - (3y^2 + 3x + 8)$ Explain the steps for the two problems above. 	<p>3. </p> <p>Arrange it into virtual manipulative to show results $(x + 2)^2$ dan $(2x + y)^2$! What is the result? How do you solve this problem?</p>

3.2. Research by applying revised results

The implementation of the study occurred through the application of revised HLT in class VIIA throughout 2 meetings using virtual manipulative software related to algebraic operations with PBL models. The number of students in class VIIA is 24 students. Therefore, researchers divided students into 4 discussion groups heterogeneously and each group consisted of 6 students. The following is a table of implementation of research activities by applying revised HLT in class VIIA:

Table 4. Learning Activities at the First and Second Meetings in the Research class

Class/ School: VII_A / Junior High School Santo Aloysius Turi Yogyakarta			
Learning	Date and Time	Time Allocation	The Number of Student
First meeting	Monday, November 2018	12 2 × 40minutes (07.20-08.40 WIB)	23 students
Second meeting	Wednesday, November 2018	14 3 × 40minutes (07.20-09.20 WIB)	24 students

Lessons carried out by researchers in class VIIA was based on revised learning trajectories or HLTs that have been designed with virtual manipulatives using the PBL model consisting of 6 problems, namely 3 problems for learning in the first meeting and 3 problems for learning in the second meeting. Analysis of the process of implementing lessons carried out in this research class is based on the videos and field notes that the researchers have prepared. The following is a description of the learning process with virtual manipulative based on the PBL syntax in learning during the first and second meetings in the VIIA class.

3.2.1. Student orientation to problems. At this stage, both at the first and second meetings, the researcher conveyed the learning objectives to be achieved, namely students can find out the addition, subtraction and multiplication operations in the algebraic form. Then the researcher explained the activities that will be carried out by students, namely using a virtual manipulative to find out the algebraic operation. Then the researchers reviewed material related to algebra to determine the initial understanding that is held by students. Next, the researcher distributed the prepared worksheets and asked students to respond to whether or not the questions given were already understood or not to facilitate the solving of the problems. There were some students who asked questions about problems 1 to 3, so the researcher explained the purpose of the question on these problems, namely: on the first problem students are asked to simplify the virtual form then declare it into algebraic form, on problem 2 students are asked to determine the addition and subtraction results from the arrangement of boxes in the virtual then declare in the form of algebra, and on the third problem students are asked to determine the results of the reduction and summation of the algebraic form into the virtual form and then determine the steps taken to solve. At the second meeting this concerned operation of the algebraic multiplications.

3.2.2. Organizing students for learning. In this stage, researchers asked students to form heterogeneous groups and discuss. The group formed as many as 4 groups consisting of 6-7 students. The researcher distributed laptops to each group to assist in solving the problem given. The researcher directed students on how to open the virtual manipulative site, including opening the internet browser, reaching the national library virtual manipulative (LNVM) website through a search engine, and clicking on the algebra tile on the LNVM website.



Figure 2. Students discuss in groups

3.2.3. Guiding individuals and group investigation

3.2.3.1. The first meeting. In the first meeting, the researcher walked around to monitor the course of the group discussion in solving the problem given. The researcher provided each group the freedom and opportunity to express their opinions. In the first meeting the researcher gave 3 problems to be explored by students related to the addition, operation, and reduction of algebraic forms. From the four groups in the research implementation class, there are a number of problem-solving strategies carried out by these groups, as in the following example:

No. 2) Hasil diskusi - bentuk Aljabar :

(gambar pertama) $2x + 4y + 5$
 (gambar kedua) $6x + 3y + 12$

bentuk Aljabar penjumlahan :

$$(2x + 6x) + (4y + 3y) + (5 + 12)$$

$$8x + 7y + 17$$

bentuk Aljabar :

(gambar pertama) $2x - 4y - 5$
 (gambar kedua) $6x - 3y - 12$

bentuk Aljabar pengurangan

$$(2x - 6x) - (4y - 3y) - (5 - 12)$$

$$-4x - 1y - (-7)$$

Figure 3. The first strategy for problem 2 worked on by one of the groups in the class VII_A

Based on the results of discussion group on problem 2, it can be seen that group has changed the arrangement of the virtual boxes into algebraic forms on the sum correctly, but has used the wrong approach in the reduction operation through the use distributive properties, therefore the algebraic form obtained is not appropriate. In the process of solving a given problem, the first group determines the algebraic form of the virtual box arrangement, namely the first arrangement becomes $2x + 4y + 5$ and the second composition becomes $6x + 3y + 12$. Then using associative properties, states that the sum of the algebraic form of operations is $(2x + 6x) + (4y + 3y) + (5 + 12)$, so that the result is $8x + 7y + 17$. Then in the subtraction operation, group converts the terms into a reduction, namely in the first image $2x - 4y - 5$ and in the second picture $6x - 3y - 12$. Then the group uses associative properties to reach $(2x - 6x) - (4y - 3y) - (5 - 12)$, obtaining the result $(-4x) - 1y - (-7)$. Based on group's answer to this problem, group has been able to state the algebraic form correctly in the form of addition, but in the form of algebraic reduction it is not appropriate to use the concept of distributive nature. Group has been able to group similar tribes according to their groups even though the operations used to connect each tribe are not correct. Group can already state the arrangement of the virtual boxes into an algebraic form with symbols and words. Group can use certain procedures in determining the resolution of a given problem. Based on the description above, it can be concluded that group already has the steps to resolve the problem even though it is not right.

2. a. $(2x + 4y + 4) + (6x + 3y + 12) = (2+6)x + (4+3)y + (4+12)$
 $= 8x + 7y + 16$

b. $(2x + 4y + 4) - (6x + 3y + 12) = (2-6)x + (4-3)y + (4-12)$
 $= -4x + y + (-8)$

Figure 4. The second strategy for problem 2 worked on by one of the groups in the class VII_A

Based on the results of group discussion on problem 2, it can be seen that group has changed the arrangement of the virtual boxes into algebraic forms based on addition and subtraction which are not correct, namely units in the first algebraic form there are 5 composed of 5 unit boxes but group writes 4, thus influencing the answer that is given. In the process of completing the summation operation, that group uses the distributive properties, namely $(2 + 6)x + (4 + 3)y + (4 + 12)$, so that it gets $8x + 7y + 17$. In the subtraction operation, group converts the terms into a subtraction form $(2x + 4y + 4) - (6x + 3y + 12)$ then uses the distributive properties $(2 - 6)x + (4 - 3)y + (4 - 12)$, so

$-4x + y + (-8)$ are obtained. Based on group's answer to these two problems, group can already state the algebraic form even though it is not correct because it lacks one unit box but does the addition and subtraction operation correctly. Group has been able to group similar tribes according to the group. Group can already state the arrangement of the virtual boxes into an algebraic form using symbol representation. Group can use certain procedures until it finds the right answer. Based on the description above, it can be concluded that group has been able to solve the problem given.

3.2.3.2. *The second meeting.* In the second meeting, the researcher walked around to monitor the course of the group discussion in solving the problem given. The researcher provided freedom and opportunity to each group to express ideas in solving the problem given. In the second meeting, the researcher gave three problems to be explored by students. Of the three problems there are several problem-solving strategies carried out by students, such as the example in the first problem below:

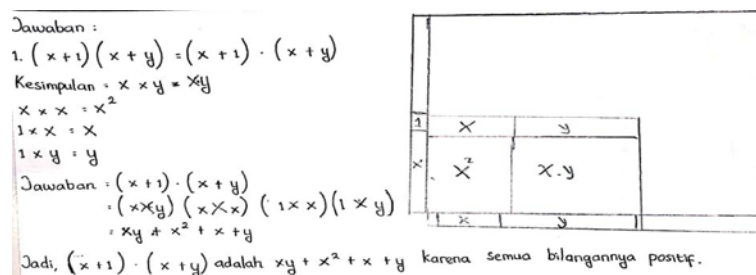


Figure 5. The first strategy for problem 1 worked on by one of the groups in the class VII_A

Based on the results of group discussion on problem 1, it can be seen that in solving the given problem, group writes the completion process using virtual manipulative starting from the determination of the algebraic form by multiplication, creates the virtual image, then writes the multiplication process $(x + 1)((x + y))$, which links each variable by writing $((x \times y)(x \times x)(1 \times x)(1 \times y))$. Group then concludes the results of multiplying two algebraic forms from $(x + 1)((x + y))$ is $x^2 + xy + y$ because all numbers are positive. Based on the results of discussion group on the first problem, group has been able to express the concept of the area of rectangles, the sum of algebraic forms, and multiplication of algebraic forms used to solve the given problem. Group has been able to classify similar tribes and associate one variable with another variable in the algebraic multiplication form. Group has been able to express the problem given in the form of images, words, and symbols. Group has been able to use certain procedures so that it can solve the problem given. Based on the description above, it can be concluded that in the case of problem 1, group has been able to solve the problem given correctly.

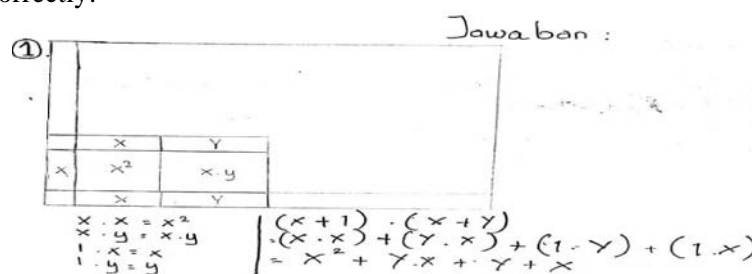


Figure 6. The second strategy for problem 1 worked on by one of the groups in the class VII_A

Based on the results of group discussions on problem 1, it was observed that the in solving the problem given the group wrote the virtual image, then concluded the results of multiplying the two

algebraic terms from $(x + 1) \cdot (x + y)$ is $(x \times x) + (x \times y) + (1 \times y) + (1 \times x)$. This leads the group to conclude the result is $x^2 + xy + y + x$. Based on the results of group discussions on the first problem, the group was able to express the concept of a broad rectangle, the sum of the algebraic forms, and the multiplication of algebraic forms used in solving the problem given. Groups have been able to classify similar tribes and associate between one variable and another variable in the multiplication of algebraic forms. The group has been able to state the problem given in the form of images and symbols. The group has been able to use certain procedures so that they can solve the problem given. Based on the description above, it can be concluded that in the case of problem one, the group has been able to solve the problem given correctly.

3.2.4. Develop and present result. In this stage, the learning process that occurred in the research class among researchers and students at both the first and second meetings is the following: (1) The researcher provides an opportunity to the group to present their results; (2) Advanced groups are appointed in accordance with the settlement strategies carried out by each group; (3) The researcher provided opportunities for other groups to provide questions and comments on the results of presentations from advanced groups.

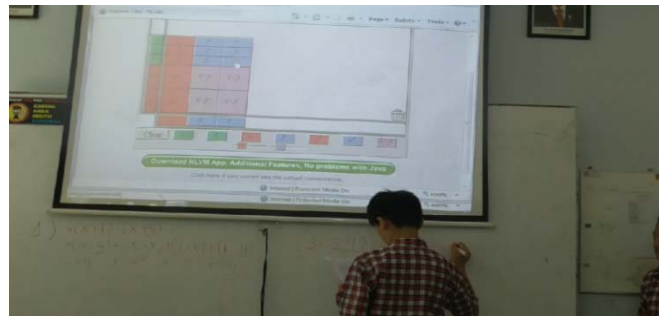


Figure 7. Students present the result of the answers in front of the class

3.2.5. Analyze and evaluate the problem-solving process. At this stage, the learning process that occurred in the research class is appropriate, namely: The researcher reads the results of the presentation that has been done by the advanced group. Then the researcher emphasizes the right results. Furthermore, the researcher together with students make conclusions from the learning process that has been carried out in accordance with the learning objectives to be achieved.



Figure 8. Researchers provide conclusions from the results of student answers

4. Conclusion

Based on the results and discussion described in the learning design using virtual manipulative with a Problem Based Learning model, we can determine that this model can help students to understand the

associative and distributive concepts used to simplify the form of algebra. In this design, students are first given the opportunity to access virtual manipulatives to solve the problem given. Then, using the problem solving process, similar tribes of students are able to carry out associative and distributive operations to simplify algebraic operations through the unknowing use of associative and distributive properties. This is also true of multiplication of algebraic forms.

The results of this study indicate that the learning process goes well according to the HLT that the researcher designed using the stages of Problem Based Learning. Therefore, the use of the virtual manipulative with PBL model can help students to construct their knowledge to understand associative and distributive properties used to simplify algebraic forms.

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