

Differences in Improving Students' Problem-Solving Ability Using Problem Based Model Learning with Cooperative Learning Type Numbered Heads Together Reviews from Gender

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Abstract

This study aims to analyze the differences in the increase in problem-solving abilities between students who are given the problem-based learning model and those given the numbered heads together learning model in terms of gender and analyze the student's answer process in solving problems on problem-solving abilities given the problem based learning model and those given numbered heads together learning model. The data were obtained through tests in the form of descriptions, with the reason that through this essay test, it could be seen that students 'thought processes and students' accuracy through the steps taken in solving the questions. The test instrument developed by researchers from the Two Variable Linear Equation System material will be used to measure problem-solving abilities. Data were analyzed by ANACOVA test. The population in this study were all students of class VIII SMP Private Bina Satria Mulia Medan. While the sample in this study was class VIII-1 as the experimental class 1 with the Problem Based Learning (PBL) learning treatment and class VIII-2 as the experimental class 2 which was treated with the Numbered Heads Together (NHT) learning model. Based on the results of the covariance analysis for the model, it was obtained that $F_{count} = 57.301$; $db = (1.55)$, and $p\text{-value} = 0.000$. Because of the sig level. $0.000 < 0, 05$ then H_0 is rejected and H_1 is accepted. Thus it can be concluded that there are differences in mathematical problem solving abilities between students who are given Problem Based Learning (PBL) learning and Numbered Heads Together (NHT) learning after controlling the pretest. Descriptively, the group average for Problem-Based Learning (PBL) learning is 80.08 and for the Numbered Heads Together (NHT) learning group is 75.67. While the results of the descriptive research based on gender in the experimental class I and experiment II showed that the problem solving abilities of male students were higher than female students. In the experimental class I, the mean score of male students was 81.47 and female students were 78.27. In the experimental class II, the mean score of male students was 77.22 and female students were 73.33.

Keywords: Mathematical Problem Solving Ability, Problem Based Learning (PBL), Numbered Heads Together (NHT), Gender

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1. Introduction

The importance of education is a measure of the progress of a nation. A developed nation is a nation that has quality human resources, both in terms of spiritual, intelligence and skills. So that with quality human resources, a nation will be able and proactive in responding to the challenges of the ever-changing times. To develop quality human resources, a quality education is also needed. One way that can be done to achieve this goal is continuous renewal in the field of education, especially mathematics.

The Indonesian government has made various efforts to improve the quality of teaching and improve student mathematics learning outcomes, because mathematics is a very important science in every level of education pursued by every Indonesian citizen. The government's efforts are to develop curricula, provide training to teachers, complete educational infrastructure and even improve teacher welfare. Along with the development of the internet, learning strategies have shifted and various information and communication technology-based learning strategies have emerged from e-learning models, smart classroom technology, virtual classrooms, belded learning, etc. (Fitri & Zahari, 2019).

Students think that mathematics is a boring and difficult subject, so it is necessary to cultivate the perception that mathematics is not a difficult thing. In everyday life, we will not be separated from the problem, so problem solving is the main focus in learning mathematics. In the era of globalization, someone who is able to understand and solve mathematical problems will have high opportunities and choices in shaping the future. Mathematical skills open up a productive future. All students should have the opportunity and support to study mathematics in depth and understanding. Standard mathematical skills that students must have in learning mathematics are problem solving, reasoning and proof, communication, connections and representation (NCTM in Dewi, Susanto, and Lestari, 2015).

Through good mathematics education, students can indeed obtain various kinds of provisions in facing challenges in the global era. In the 2013 curriculum itself, the use of technology in learning became something that was highly recommended. The learning process in the 2013 curriculum requires students to participate actively and provide sufficient space for students' creativity, interests, and talents (Fitri, Syahputra, & Syahputra, 2019).

According to Komalasari (in Maisyaroh, Surya, Syahputra, 2017) problem solving is the process of applying previously acquired knowledge into new and different situations. Every student must have problem-solving abilities so that they are accustomed to facing various problems, both routine and non-routine problems in mathematics, problems in other fields of study or problems in everyday life that are increasingly complex. The importance of having this ability is reflected in Branca's statement (in Hendriana & Soemarmo, 2014) that solving mathematical problems is one of the important goals in learning mathematics even the process of solving mathematical problems is at the heart of mathematics. In line with the previous opinion, Sagala (in Wahyu, Sahyar, and Ginting, 2017) states that implementing problem solving in the learning process is important, apart from trying to answer questions or solve problems, students are also motivated to work hard.

Based on the results of observations made by researchers at SMP Bina Satria Mulia, when working on test questions, most students found it difficult to answer math problems given by the teacher, especially on non-routine questions. This indicates that the students' problem solving abilities are still low. The low ability of student problem solving will result in low student learning outcomes. Students are accustomed to being faced with routine problems that can be solved by direct algorithms, so when they are faced with non-routine questions, they feel confused and have difficulty finding solutions to the problems given, because there is no direct algorithm to solve them. This can be seen from the results of observations of a grade VIII junior high school student in answering questions about the algebraic form operation material.

From the conclusion of the results of the students' answers, the students' mathematical problem solving abilities were still low, even the students' initial mathematical knowledge was still low. Often a student has difficulty understanding certain knowledge, one of the causes is due to previous prior knowledge that students do not yet have. In this case, the initial knowledge becomes the main requirement and is very important for students. Nur (in Trianto, 2009) states that prior knowledge is a collection of individual knowledge and experiences gained during their learning journey, and what it brings to a new learning experience.

One of the learning models that are creative, innovative, and effective in improving students' mathematical problem solving abilities is the Problem Based Learning (PBL) model. The Problem Based Learning (PBL) model is very suitable to be applied in learning to improve students' problem solving abilities, this can be seen from the syntax or steps of learning activities in the PBL model. The syntax or steps of the learning activities are: (1) student orientation to the problem, (2) organizing students to learn, (3) assisting student investigations, (4) developing and presenting work results and (5) analyzing and evaluating the problem-solving process.

According to Tan (in Rusman, 2011), the Problem Based Learning model is a learning innovation, because in that learning, students' thinking abilities are really optimized through a systematic group or team work process, so that students can empower, hone, test and develop their thinking skills. continuously. The concept of finding answers to existing problems is found by students in their groups. In the problem-based learning process, every student is required to be responsible for his learning.

From the results of research conducted by Wahyu, Sahyar, and Ginting (2017), it was concluded that the problem-solving abilities of students after being taught using a problem-based learning model were in the moderate category, while the problem-solving abilities of students who were taught using conventional learning were classified as very low. This shows that the problem-solving abilities of students who are taught using a problem-based learning model are better than students who are taught using conventional learning.

Likewise, research conducted by Yanti (2017) concluded that the mathematical problem solving abilities of students who were taught using a problem-based learning model were better than students who were taught using

conventional learning. The contribution of the problem based learning model to students' mathematical problem solving abilities was 11% higher than students who studied conventionally. Thus, the problem-based learning model has an effect on students' problem-solving abilities.

Not only the Problem Based Learning (PBL) model that will improve problem-solving abilities, but researchers will also apply the cooperative learning model Numbered Heads Together (NHT). Learning the numbered head together model requires students to be more active, and open in various ideas to other students. According to Huda (2014) numbered head together is a variant of group discussion. In learning the numbered head together model, the characteristic is that the teacher only appoints a student who represents the group without first telling who will represent the group. This method ensures total involvement of all students so it is very good for increasing individual responsibility in group discussions (Sukmayasa, Lasmawan, & Sariyasa, 2013). The purpose of learning the numbered head together model is to provide opportunities for students to share ideas and consider the most appropriate answers. In addition to increasing cooperation between students, the numbered head together learning model can also be applied to all subjects and grade levels.

Researchers consider that the Numbered Heads Together (NHT) learning model can improve problem-solving abilities, because in the Numbered Heads Together (NHT) learning model there are four components, namely numbering each member of the group given a different number according to the number of group members so that all students in groups have the same responsibility to present the results of the discussion, ask a problem (questioning) the teacher gives a problem to be solved in a discussion with the group, think together (heads together) students discuss solving a problem and ensure that each member of the group has really mastered the material being studied, and the answering of one of the numbers is randomly called to deliver the answer from the results of the group discussion. With the four components in the Numbered Heads Together (NHT) learning model, students can more easily receive learning material and can overcome difficulties in solving math problems.

From the research conducted by Koyumah and Utomo (2016) with the title of the effect of the geogebra-assisted numbered heads together model on mathematical problem-solving abilities, it was found that students' mathematical problem-solving abilities showed that the geogebra-assisted NHT learning model was better than conventional learning models.

Problem-based learning has important differences with Numbered Heads Together (NHT) learning. In the Numbered Heads Together (NHT) learning model, findings are based on cooperation between students in groups to find a solution to the problems given by the teacher. Whereas problem-based learning begins with meaningful real-life problems where students have the opportunity to carry out investigations, both inside and outside the class as far as it is needed for problem solving. In the problem-based learning model the role of the teacher is to ask questions, provide an atmosphere of dialogue, provide research facilities, and conduct research. According to Arends (in Trianto, 2009) this activity can be carried out by teachers during class learning and through sufficient training.

Apart from the learning model factor, another factor that can affect the ability to solve mathematical problems is gender differences. Gender differences certainly cause physiological differences and affect psychological differences in learning, so male and female students certainly have many differences in learning mathematics. Where is the basic male ability in reasoning and women's ability to accuracy and accuracy in solving problems. This is in line with the opinion of Krutetski (1976) which states that men are superior in terms of reasoning and have better mathematical and mechanical abilities even though these differences are only apparent at higher levels. Meanwhile, women are superior in accuracy, thoroughness, accuracy, and thinking accuracy.

Bastable (in Fitriani, Jalmo, & Yolida, 2015) states that if student achievement is integrated with problem-solving abilities associated with a gender perspective, it can be found that male students have more interest and curiosity about problems, and have the way of solving problems is more varied than female students.

Several studies examining the effect of gender on math ability show that there are differences between men and women in learning mathematics. Research conducted by Fredman and Carlsmith (in Dewi, Saragih, & Khairani, 2017) found that men appear to be better than women in quantitative abilities and spatial comprehension abilities. The differences appear around puberty and do apply after adolescence. This difference is seen in tests of quantitative skills such as algebra, geometry, and mathematical reasoning. Meanwhile, Khaerunnisa (2016) found differences in a person's intelligence in dealing with problems (adversity quotient) between men and women. Where the adversity quotient of male students in the high and medium ability categories is classified as very high, and the low ability category is classified as high, while the adversity quotient for female students in the high, medium, and low categories is classified as very high.

Based on the above background, it is necessary to make efforts to reveal whether problem-based learning has different contributions to problem-solving abilities in terms of gender differences. That is what prompted a study to be carried out with the title: ***“Differences in Improved Problem Solving Ability Using the Problem Based Learning Model with Cooperative Learning Type Numbered Heads Together in terms of gender ”***

2. Methods

This study took two parallel classes with class VIII-1 as experimental class 1 with Problem Based Learning (PBL) learning treatment and class VIII-2 as experimental class 2 which was given the Numbered Heads Together (NHT) learning model. The experimental design in this study can be described as follows:

Table 1. Research Design

Treatment Group	Pretest	Treatment	Posttest
Experiment 1	T ₁	X ₁	T ₂
Experiment 2	T ₁	X ₂	T ₂

Information :

T₁ : Pretest

T₂ : Posttest

X₁ : Treatment model Problem Based Learning (PBL)

X₂ : Treatment model *Numbered Heads Toether* (NHT)

The population in this study were all students of Bina Satria Mulia Private Junior High School, Medan. The test instrument is in the form of a description, with the reasons through the essay test, it can be seen that students 'thinking processes and students' accuracy through the steps taken in solving the questions. The test instrument developed by researchers from the Two Variable Linear Equation System material will be used to measure problem-solving abilities. In this study, each research sample was given a test essay consisting of 4 items of pre-test and post-test that measured problem-solving abilities. The data to be analyzed in this study were the results of the student's KAM (pretest) as a companion variable and the posttest results as the dependent variable. The use of ANACOVA is because in this study using accompanying variables as independent variables that are difficult to control but can be measured together with the dependent variable.

3. Result And Discussion

The test of students' mathematical problem solving abilities was carried out twice, namely the pretest and posttest. The initial and final tests were attended by 30 people in each class so that in the data analysis the subjects of this study were 30 students, namely students who took the pretest and posttest.

The average student test scores for experimental class I and experimental class II are summarized in Table 2 below:

Table 2. Recapitulation of Average Problem Solving Ability Mathematical Students of Experiment I and Experiment II Class

No		Experiment I	Experiment II
1	Proportion of pretest scores	42,33	40,17
2	Proportion of posttest scores	80,08	75,67

For the architecture of In Table 2 it can be seen, for the mathematical problem-solving ability the average pretest and posttest scores of the students in Experiment class I were 42.33 and 80.08 If you pay attention to the average proportion of scores in the experimental class I, there is an increase in the average proportion score of 37.75, while the experimental group II, namely 40.17 and 75.67, there is an increase in the average proportion score of 35.50. The difference in the proportion of the pretest and posttest scores of the experimental group I is greater than the difference in the proportions of the pretest and posttest scores for the experimental class II. This suggests that learning using the Problem Based Learning (PBL) model can increase the achievement of students' mathematical problem solving abilities rather than learning Numbered Heads Together (NHT).

The average description of the increase in problem-solving abilities based on learning is presented in Table 2 can be seen in Figure 1 below:

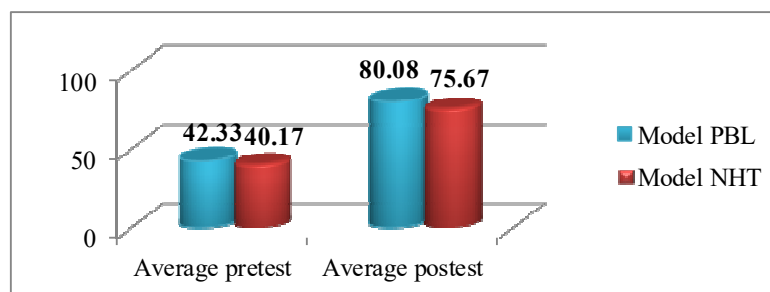


Figure 1 Bar Diagram of Differences for Improved Problem Solving Ability

The description of the average post-test score of problem-solving abilities based on gender can be seen in Table 3 below:

Table 3 Description of Average Post-test Score of Problem Solving Ability by Gender

Class	Gender	Total students	Average
Experiment I	Man	17	81,47
	Women	13	78,27
Experiment II	Man	18	77,22
	Women	12	73,33

The post test description of problem-solving abilities based on gender can be seen in Figure 2 below:

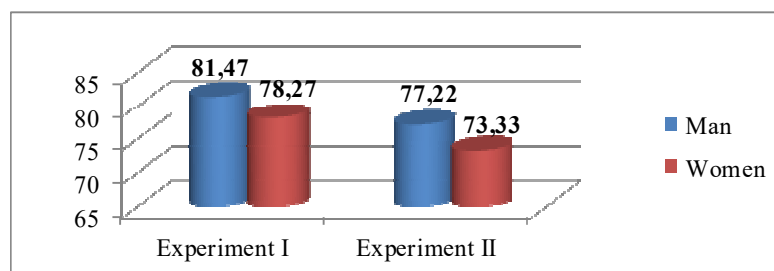


Figure 2 Average Posttest Value of Problem Solving Ability Based on Gender

Based on Table 3 and Figure 2, it can be seen that the male students in the experimental class I totaled 17 people with an average value of 81.47 and 13 female students with an average score of 78.27. This shows that the problem solving ability of male students is higher than that of female students in experimental class I. While male students in experimental class II are 18 people with an average score of 77.22 and 12 female students with a score an average of 73.33. Thus it can be stated that the problem solving ability of male students is higher than that of female students in the experimental class II.

Hypothesis testing aims to see the difference in the average problem-solving ability of students who are given the Problem Based Learning (PBL) model and students who are given the Numbered Heads Together learning model. The statistical hypothesis is as follows:

$H_0: \alpha_1 = \alpha_2$ (there is no difference in problem solving abilities between students who are taught using the PBL model and the NHT model)

$H_1: \alpha_1 \neq \alpha_2$ (there are differences in problem solving abilities between students who are taught using the PBL model and the NHT model)

For the results of the covariance analysis using the F statistic with the formulas and criteria that have been determined with the help of the SPSS 21 program, it can be seen in Table 4 below:

Table 4. Covariance Analysis for Complete Design of Mathematical Problem Solving Ability

Tests of Between-Subjects Effects

Dependent Variable: postes

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Squared	Eta
Corrected Model	2109,481 ^a	4	527,370	255,934	,000	,949	
Intercept	6092,795	1	6092,795	2956,847	,000	,982	
Model	118,073	1	118,073	57,301	,000	,510	
Gender	2,883	1	2,883	1,399	,242	,025	
model * gender	13,561	1	13,561	6,581	,013	,107	
Pretes	1632,489	1	1632,489	792,251	,000	,935	
Error	113,331	55	2,061				
Total	366093,750	60					
Corrected Total	2222,813	59					

a. R Squared = ,949 (Adjusted R Squared = ,945)

Based on the results of the covariance analysis for the model, it was obtained that $F_{count} = 57.301$; $db = (1.55)$, and $p\text{-value} = 0.000$. Because of the sig level. $0.000 < 0, 05$ then H_0 is rejected and H_1 is accepted. Thus it can be concluded that there are differences in mathematical problem solving abilities between students who are given Problem Based Learning (PBL) learning and Numbered Heads Together (NHT) learning after controlling the pretest.

Because H_0 was rejected or there were differences between the treatment groups after controlling for the covariate (pre-test), a further test was carried out with the Anacova t-test statistic. This follow-up test aims to determine which of the two treatment groups differed significantly. The statistical hypothesis is as follows:

$H_0: \alpha_1 \leq \alpha_2$ (problem solving ability among students given a problem based learning model is lower than students given the numbered heads together learning model in terms of gender)

$H_1: \alpha_1 > \alpha_2$ (the problem solving ability among students who were given a problem based learning model was higher than students who were given the numbered heads together learning model in terms of gender)

For the results of ANAKOVA further test analysis using the F statistic with the formulas and criteria that have been determined with the help of the SPSS 21 program can be seen in Table 5 below:

Table 5. Results of ANAKOVA Advanced Test of Mathematical Problem Solving Ability

Parameter Estimates

Dependent Variable: postes

Parameter	B	Std. Error	T	Sig.	95% Confidence Interval		Partial Squared	Eta
					Lower Bound	Upper Bound		
Intercept	50,278	,918	54,771	,000	48,438	52,117	,982	
Pretes	,640	,023	28,147	,000	,594	,685	,935	
[gender=1]	-,509	,557	-,913	,365	-1,626	,608	,015	
[gender=2]	0 ^a	.	.	.	.	.	.
[model=1] * [gender=1]	3,856	,486	7,940	,000	2,883	4,830	,534	
[model=1] * [gender=2]	1,912	,585	3,270	,002	,740	3,083	,163	
[model=2] * [gender=1]	0 ^a	.	.	.	.	.	.
[model=2] * [gender=2]	0 ^a	.	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

Based on the results of the analysis in Table 5, the t-test statistical price is obtained, namely $(model = 1) * (gender = 1)$ with $t = 7.940$ and $p\text{-value} = 0.000 < 0.05$, and for $(model = 1) * (gender = 2)$ $t_{count} = 3,270$ and $p\text{-value} = 0.002 < 0.05$, this means that H_0 is rejected. Thus the mathematical problem solving abilities of students taught by the Problem Based Learning (PBL) model are higher than students taught with the Numbered Heads Together (NHT) model in terms of gender after controlling the pretest.

Based on the student answer sheet regarding the mathematical problem solving ability test, it is obtained a general description that the students' answers to the Problem Based Learning (PBL) model and Numbered Heads

Together (NHT) learning are different. In more detail, the following shows the results of the mathematical problem-solving ability test which are categorized into item indicators, namely: students know the elements that are known and what are asked, students can develop mathematical problems or compile mathematical models, students can apply strategies to solve problems, and students can re-check the correctness of the answer he got.

Item number 1

This problem measures students' abilities with the aspect of students knowing the elements that are known and asked, students can compose mathematical problems or develop mathematical models, students can apply strategies to solve problems, and students can check the correctness of the answers they get.

Results of the Analysis of the Student's Answer Completion Process:

<p>The process of completing answers in the experimental class I In question no 1 point a. For point a, students write down the information clearly and correctly. For points b, and c, students already understand the problem solving strategy according to their mathematical model and can solve problems well and can check the correctness of the answers.</p>	<p>The process of completing answers in the experimental class II In question no 1 point a. For point a, students write down the information clearly and correctly. For points b, and c students already understand the problem solving strategy according to their mathematical model and can solve problems well and can check the correctness of the answers.</p>
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Item number 2

This problem measures students' abilities with the aspect of students knowing the elements that are known and asked, students can compose mathematical problems or compile mathematical models, students can apply strategies to solve problems, and students can check the correctness of the answers they get.

Results of the Analysis of the Student's Answer Completion Process:

<p>The process of completing answers in the experimental class I In question no 2 point a. For point a, students write down the information clearly and correctly. For points b, and c students can formulate a mathematical model correctly and apply a solution strategy, but some of the answers obtained are not correct.</p>	<p>The process of completing answers in the experimental class II In question no 2 point a. For point a, students write down the information clearly and correctly. For points b, and c students can formulate a mathematical model correctly and apply a solution strategy, but some of the answers obtained are not correct.</p>
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Item number 3

This problem measures students' abilities with the aspect of students knowing the elements that are known and asked, students can compose mathematical problems or compile mathematical models, students can apply strategies to solve problems, and students can check the correctness of the answers they get.

Results of the Analysis of the Student's Answer Completion Process

<p>The process of completing answers in the experimental class I In question no 3 point a. For point a, students write down the information clearly and correctly. For points b, and c, students already understand the problem solving strategy according to their mathematical model and can solve problems well and can check the correctness of the answers.</p>	<p>The process of completing answers in the experimental class II In question no 3 point a. For point a, students write down the information clearly and correctly. For points b, and c students can formulate a mathematical model correctly and apply a solution strategy, but some of the answers obtained are not correct</p>
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Item number 4

This problem measures students' abilities with the aspect of students knowing the elements that are known and asked, students can compose mathematical problems or compile mathematical models, students can apply strategies to solve problems, and students can check the correctness of the answers they get.

Results of the Analysis of the Student's Answer Completion Process:

The process of completing answers in the experimental class I

In question no 4 point a. For point a, students write down the information clearly and correctly.

For points b, and c students can formulate a mathematical model correctly and apply a solution strategy, but some of the answers obtained are not correct.

The process of completing answers in the experimental class II

In question no 4 point a. For point a, students write down the information clearly and correctly.

For points b, and c students can formulate a mathematical model correctly and apply a solution strategy, but some of the answers obtained are not correct.

Discussion of the research results will parse the positives and obstacles found in the field in Problem Based Learning (PBL) and Numbered Heads Together (NHT) learning. The learning factor is one of the things that affects students' mathematical problem-solving abilities and habits of mind. Each stage in the Problem Based Learning (PBL) and Numbered Heads Together (NHT) learning model contributes to improving students' abilities. So, the five phases in Problem Based Learning (PBL) and the four phases in Numbered Heads Together (NHT) learning are actually applied in the learning process so that it can improve students' mathematical problem solving abilities. Where the four indicators of mathematical problem solving abilities include; 1) Students can identify elements that are known, and which are asked, 2) Students can formulate mathematical problems or compile mathematical models, 3) Students can apply strategies to solve problems, and 4) students can check the correctness of the answers.

In research during the learning process in each class, students work together in small groups. This is supported by Vygotsky's learning theory which gives a more important place to the social aspect with other friends, spurring the formation of new ideas and enriching students' intellectual development. Vygotsky emphasized the importance of the relationship between individuals and the social environment in the formation of knowledge, according to him, that social interaction, namely the interaction of the individual with other people, is the most important factor that can trigger one's cognitive development. Vygotsky argues that the learning process will occur efficiently and effectively when children learn cooperatively with other children in a supportive atmosphere and environment, under the guidance of someone who is more capable, teacher or adult.

In Problem Based Learning (PBL) a teacher must be able to help students solve problems in the form of problems, make students more active in teaching and learning activities, motivate students to express their ideas and opinions. Albanese & Mitchell (1993) say that Problem Based Learning (PBL) is an instructional method characterized by the use of problems as a context for students, working in small groups, learning problem-solving skills and increasing their knowledge. To develop problem-solving abilities and motivation in mathematics learning, teachers must strive for learning by using learning models that provide great opportunities and encourage students to practice mathematical problem-solving skills and students' habits of mind. Among the learning models based on the constructivist approach, Problem Based Learning (PBL) has provided important opportunities to improve active learning and higher-order thinking skills, including critical thinking, creative thinking, and problem solving (Kumar, 2010; Tan, 2007; Barak et al. al, 2007).

During the learning process Problem Based Learning (PBL) and the teacher acts as a resource and facilitator. The teacher goes around among the groups to see if the students in each group can work on the LKPD that is presented and help any difficulties they face in their interactions in the group. The teacher's next role is to build students' knowledge / skills to collect appropriate information, carry out observations to solve problems.

The results of the research show that learning with the Problem Based Learning (PBL) model encourages students to learn more enthusiastically because each student has a very large responsibility that plays a role in

each group, and in the end can develop mathematical problem solving abilities and students' habits of mind. . This is in line with Barrow (in Olaoye, 2015) who stated that the PBL curriculum was developed to motivate students, help students understand the importance of learning for future roles, maintain a higher level of encouragement in the learning environment, and to show students the importance of being responsible, responsible and skillful attitude.

The research, which was conducted at Bina Satria Mulia Private Junior High School, Medan, involved two classes, namely the experimental class I in class VIII-1 and the experimental class II in class VIII-2. Before giving treatment to the two experimental classes, the first step taken was giving students a pretest to find out the initial knowledge of each student in each experimental class. After the pretest was carried out, the next stage was to give different treatment to the experimental class I and the experimental class II, then the two classes were given a posttest to determine the students' mathematical problem solving abilities after being treated.

Students' mathematical problem solving abilities can be measured through the students' ability to solve a problem using mathematical problem solving indicators, namely: Students can identify elements that are known and those that are asked, students can formulate mathematical problems or develop mathematical models, students can apply strategies to solve problem, and students can re-check the correctness of the answer.

Based on the results of descriptive data analysis after being given treatment, it was found that the average mathematical problem solving ability of the pretest and posttest students' pretest and posttest scores was 42.33 and 80.08. If you pay attention to the average proportion of scores in the experimental class I, there is an increase in the average proportion score of 37.75, while the experimental group II, namely 40.17 and 75.67, there is an increase in the average proportion score of 35.50. The difference in the proportion of the pretest and posttest scores of the experimental group I is greater than the difference in the proportions of the pretest and posttest scores for the experimental class II.

While the results of the descriptive research based on gender showed that the male students in the experimental class I totaled 17 people with an average score of 81.47 and 13 female students with an average score of 78.27. This shows that the problem solving ability of male students is higher than that of female students in experimental class I. While male students in experimental class II are 18 people with an average score of 77.22 and 12 female students with a score an average of 73.33. Thus it can be stated that the problem solving ability of male students is higher than that of female students in the experimental class II. This suggests that learning using the Problem Based Learning (PBL) model can increase the achievement of students' mathematical problem solving abilities rather than learning numbered heads together.

Based on the results of the covariant analysis data, it shows that there is a significant difference in the improvement of mathematical problem solving abilities between students who are taught with the Problem Based Learning (PBL) learning model and Numbered heads Together (NHT) learning, mathematical problem solving abilities that get Problem Based Learning (PBL) was higher than the class that was given Numbered heads Together (NHT) learning. This difference can be a reference for decision making that the mathematical problem solving ability in the Problem Based Learning (PBL) learning class is higher than the Numbered Heads Together (NHT) learning.

The results of this study are in line with Julita's (2018) research entitled "Increasing Mathematics Solving Ability and Learning Outcomes through Problem Based Learning". The following conclusions are obtained: 1) There is an increase in problem-solving abilities and student learning outcomes about the three-variable linear equation system (SPLTV) through Problem Based Learning (PBL) in class X MIPA-1 SMA Negeri 10 Bogor; 2) The activeness of students in the learning process through problem based learning (PBL) is better than before using PBL; and 3) Improved problem solving skills and student learning outcomes about the three-variable linear equation system (SPLTV) through the Problem Based Learning (PBL) method in class X MIPA-1 SMA Negeri 10 Bogor has achieved the indicators of the success of the targeted action.

Another research conducted by Hendriana, Johanto, and Soemarmo (2018) entitled "The Role Of Problem-Based Learning To Improve Students' Mathematical Problem-Solving Ability And Self Confidence". The results of his research showed that the problem-solving ability, improvement, and self-confidence of students who were treated with the Problem Based Learning (PBL) model obtained better results than students who were taught by conventional learning. Another finding is that there is a high association between math problem solving abilities and self-confidence, and students show a positive perception of Problem Based Learning (PBL).

From the above explanation, it shows that Problem Based Learning (PBL) learning has a greater influence in developing problem-solving abilities. This is due to several things, one of which is the characteristics of PBL learning which can encourage students to self-evaluate both the results and the learning process, and can provide

opportunities for students to apply the knowledge they already have to other groups. In addition, at the beginning of the first meeting learning in the experimental class 2 students took a long time to follow the mathematical stages found in the LKPD, this is because students are not used to solving problems with the mathematical stages found in LKPD, but students continue to experience progress that is getting better in the LKPD. thought process individually and in groups. Through the stages in the LKPD, understanding mathematical problems by only observing problem solving problems initially feels difficult for students because they are not used to it.

Moreover, in terms of identifying the elements that are known and asked in the questions, students need a long time to find them. However, with the guidance of the teacher, most students who are taught with the PBL learning model are better able to understand the concepts of the material they are learning so that they can improve students' mathematical problem solving abilities. In addition, in learning with PBL learning, students can learn well together. Students are not too difficult to follow the existing learning process, so that with teacher guidance they can collaborate with friends in their respective groups. Meanwhile, in a class that is taught using the Numbered Heads Together (NHT) learning model, students expect more guidance from the teacher to work together and help each other in a group to succeed together. This means that learning using PBL is effective in improving mathematical problem solving abilities for students.

WOZIP, a holarchy consisting of machinery holon (MH), operational holon (OH), forecasting holon (FH), and sizing holon (ZH) is delineated in Figure 1. The WOZIP is itself regarded as the supra-holon, which allows and coordinates the information transfer as well as the interactive computing between the four sub-holons. In the normal process flow, MH (i.e. the order holon) will supply the work information based on customer specifications for OH (i.e. the resource holon) to prepare the workforce that will handle the machines. At the threshold of workforce sizing, both the MH and OH, which compose the input holon, will generate their respective data items via Equations (1) to (3), for the use of FH (i.e. the intermediate product holon) to conduct the exponential smoothing. The forecast outcomes of Equation (4) of FH will be channelled into ZH (i.e. the final product holon), which completes the procedure using Equation (5) — adjust the workforce size of OH. Essentially, the FH and ZH belong to the output holon. Some negotiation might take place around the beginning and the end of the process flow, between the MH and the customer side (i.e. the external environment) as well as between the ZH and the human resources division (i.e. the internal environment). As the whole process will repeat for every production period, a database has to be integrated into each of the holons for efficient information storage and retrieval.

5. Conclusion

A functional structure made up of holons is called holarchy. The holons, in coordination with the local environment, function as autonomous wholes in supra-ordination to their parts, while as dependent parts in subordination to their higher level controllers. When setting up the WOZIP, holonic attributes such as autonomy and cooperation must have been integrated into its relevant components. The computational scheme for WOZIP is novel as it makes use of several manufacturing parameters: utilisation, disturbance, and idleness. These variables were at first separately forecasted by means of exponential smoothing, and then conjointly formulated with two constant parameters, namely the number of machines and their maximum utilisation. As validated through mock-up data analysis, the practicability of WOZIP is encouraging and promising.

Suggested future works include developing a software package to facilitate the WOZIP data input and conversion processes, exploring the use of WOZIP in the other forms of labour-intensive manufacturing (e.g. flow-line production and work-cell assembly), and attaching a costing framework to determine the specific cost of each resource or to help minimise the aggregate cost of production.

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