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The effectiveness of Numbered Heads Together towards the mathematical problem-solving ability

Muhammad Istiqlal[a], Tri Kustianingsih[a]

[a] *Faculty of Tarbiyah and Teacher Training – Institut Agama Islam Negeri Salatiga, Jl. Lkr. Sel. Salatiga No.Km. 2, Pulutan, Kec. Sidorejo, Kota Salatiga, Jawa Tengah 50716, Indonesia*

* *E-mail address: m.istiqlal@gmail.com*

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Abstract

This study aims to determine whether the cooperative learning model type Numbered Heads Together (NHT) is more effective than the conventional learning model towards the mathematical problem-solving ability of VII grade of Salatiga State Junior High School 5 students the academic year 2019/ 2020. This research was Quasi-Experimental type with Non-Equivalent Control Group Design. The instrument of this study was a problem-solving ability test, which consisted of pre-test and post-test. Post-test results obtained an average of 73.24 in the experimental class and 58.62 in the control class. In other words, the average experimental class was higher than the control class. This result was confirmed by the Mann-Whitney U test that obtained a sig (2-tailed) value of 0.00 < 0.05, so H0 was rejected, while H1 was accepted; it meant that there was a difference in the average mathematical problem-solving ability of students between the experimental and the control class. Additionally, the average N-Gain of the experimental class was 0.54, and the control class was 0.29. The average increase in the experimental class was higher than the control class, and there were differences. As the Mann-Whitney U N-Gain test confirmed that obtained sig (2-tailed) value of 0.00 <0.05 so H0 was rejected, and H1 was accepted. Thus there was a difference in the average increase of students' mathematical problem-solving ability between experimental and control classes.

1. Introduction

Mathematics is one of the natural science (IPA) branches that have a very important role in the development of Technology and Science (IPTEK) (Ruwanto, 2016). Hidayat & Sumarno (2013) say that mathematics can create students become more logical, critical, rational, and confident in thinking. It is one of the most important components in the education field. To achieve the objectives of mathematics learning, it certainly requires several tools to lead all of the educational resources to perform the concrete steps. The Indonesian government has already supported and clarified the direction of mathematics learning objectives in Indonesia through the Minister of Education Regulation (Permendiknas) No. 22 2006.

In Permendiknas No. 22 2006, the objective of mathematics learning in Indonesia is students are expected to be able to:

1. Understand the concept of mathematics, explain the relevance between the concepts, and apply the concepts or algorithms flexibly, accurately, efficiently, and precisely in problem-solving.
2. Use the reasoning on pattern and properties, perform mathematical manipulation in making a generalization, compiling evidence, or explaining mathematical ideas and statements.
3. Solve the problems that cover the ability to understand the problems, to design the mathematical models, completing a mathematical model, and interpreting the solution.
4. Communicate the ideas through symbols, tables, diagrams, or other media to clarify a situation or problem.

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5. Appreciate the use of mathematics in real life, have curiosity, attention, and interest to learn mathematics, and always be tenacious and confident in solving the problems.

National Council of Teacher Mathematics (NCTM) explains the objective of mathematics learning is to develop the ability of (1) mathematical communication, (2) mathematical reasoning, (3) mathematical problems solving, (4) mathematical connection, and (5) mathematical representation (Rohman, 2016: 4). Based on those objectives, students must have one of the important competencies, namely problem-solving. Problem-solving is one of the alternatives to find a solution to achieve the objectives that require well preparation, creativity, knowledge, and ability as well as application in real life. This ability is very useful for students in learning mathematics, not only for those who want to explore mathematics, but also those who will apply it in daily life.

Although the ability of problem-solving is an important aspect of mathematics learning, in fact, it shows that students' problem-solving has not shown good results. It is proved by the Programme for International Student Assessment (PISA) in 2015 that students' problem-solving ability in Indonesia is ranked 63 of 69 participating countries. The questions provided by PISA are problem-solving types. Thus the result of PISA's study also informs that students in Indonesia have not been able to answer the material of mathematics test in the form of problem-solving types (Kharisma & Susilowati, 2018: 3).

Regarding the result of observation during Field Experience Practice (PPL) in SMP N 5 Salatiga, VII grade students experienced difficulties in completing the problem-solving questions. It can be seen when teachers give high-level exercises; there were only 25% of students who were able to correctly complete the questions, while the others were still experiencing difficulties. Several students were uninterested in trying to complete the questions since the questions were difficult. They only relied on their friends' answers or waited for the teacher's explanation without trying to find the answers.

Alternatively, to overcome the low problem-solving ability of VII grade students of SMP Negeri 5, Salatiga is by applying the more innovative learning model, namely cooperative learning model with Numbered Heads Together (NHT) type. It has several advantages, including every student, becomes more ready in following the learning process, follows the discussion seriously, and exchanges ideas and finds alternatives for problem-solving. Then, those alternatives can be used and have positive relationships that are cooperative relation both between students in the group; in which smart student helps to explain the material to less-smart students, as result students are able to arise courage to positively interact, or between students and teachers.

This study tries to answer several problems, namely (1) are there any differences in average of students' mathematical problem-solving ability in cooperative model with NHT type and conventional model classes?, and (2) are there any differences of an average of problem ability increase in NHT and conventional classes?.

1.1. The Effectiveness of Learning

Effectiveness comes from *effective,* which means successful or precise. According to Mulyasa (Erfian, 2011: 23-24), effectiveness is a condition that contains an understanding of the effects or consequences desired by someone. Effectiveness is related to achieve the targets related to quality, quantity, and time. It is a measure that gives an illustration of how far the target achieved. In brief, the effectiveness of learning is a measure of success obtained after the implementation of the learning process.

Mulyasa (Aziz, 2017: 11-12) explains to find out the effectiveness of learning can be done in several ways; one of them is a test. The result of tests can be used to evaluate many aspects of the learning process. Effective mathematics learning, students not only receive formula and then memorize it but also actively involved in the learning process. Therefore in learning, an appropriate learning method needs to be considered, so students actively construct their knowledge. A learning method is effective if it can give optimal results towards the aspect measured after it is used.

1.2. Cooperative Learning Method

Dahlan (Sutikno, 2014: 57-58) suggests that the learning model is a plan or pattern that is used in compiling curriculum, arranging subject matters, and giving direction to teachers in class in learning settings or others. Soekanto and Winataputra (Sutikno, 2014: 57-58) interpret the learning model as a conceptual framework that illustrates a systematic procedure in organizing learning experience to achieve certain learning objectives and function as a guide for learning designers and teachers in planning and implementing teaching and learning activities. Shortly, a learning model is a design or pattern in learning that is used as a guide in planning learning activities to achieve a certain learning objective.

Roger et al. (Huda, 2016: 29) argues that cooperative learning is a group learning activity, which has a principle that learning must be based on changing information socially between learning groups in which each learner is responsible for his own learning and encouraged to improve other members' learning. According to Johnson and Johnson (Huda, 2016: 31), cooperative learning means working together to achieve common goals. In cooperation, each member should try to achieve the result that can be felt by all of the group members. In a teaching context, cooperative learning is often defined as the formation of small group consists of students who are required to cooperate and enhance their own learning and others'. While Arts and Newman (Huda: 2016: 32) define cooperative learning as students' small group that cooperate in a team to overcome a problem, complete an assignment, and achieve the goal.

Based on the preliminary explanation, it can be concluded that cooperative learning consists of small groups that cooperate to overcome an assignment or a problem in which each member is responsible for their understanding and other members'. Afterward, a cooperative learning model is a design or pattern in learning which is used as a guide to making a learning plan in a small group in which each member is responsible for their own understanding and others'.

The main steps in cooperative learning can be seen in Table 1.

Table 1. The Steps of Cooperative Learning

Phase	Teacher's Behavior
1st Phase: Delivering the learning objectives and motivating students	Delivering the learning objectives and motivating the students
2nd Phase: Providing information	Providing information for students in the form demonstration or through reading
3rd Phase: Organizing students into the groups	Explain to students how to make a group and help each group to complete the assignment well.
4th Phase: Guiding group to work and learn	Guiding the learning group when completing the assignment
5th Phase: Evaluating	Evaluating the learning result about the material learned of each group
6th Phase: Giving reward	Teacher finds a way to reward the effort/ individual or group learning result/

1.3. Cooperative Learning with Numbered Heads Together (NHT) type

Cooperative learning with NHT type is one of the cooperative learning types that emphasizes on special structures that are designed to influence students' interaction pattern and has an objective to improve academic mastery. This type is developed by Spencer Kagen to involve the students in studying the material of a lesson and check their understanding of the content of the lesson (Sakti, 2014: 29)

Ibrahim (Hartati, 2015: 2) suggest three objectives of cooperative learning with NHT type, namely: a) structural academic learning result, aims to improve students' performance in academic assignments, b) recognition of diversity, aims to make students can accept their friends with various backgrounds, (c) social skill development, aims to develop students' social skills (such as: sharing tasks, actively asking the question, respecting others' opinion, willing to delivering ideas or opinion, working in a group, etc.).

Each learning model has several steps in the implementation as well as Numbered Heads Together. Siregar (2012: 35) explains the steps of NHT model from Nurhadi, as follows:

a. Step 1: Numbering
   The teacher divides the students into several groups consist of 3 – 5 students, so each student in a group has a different number.
b. Step 2: Questioning
   The teacher gives questions to students.
c. Step 3: Head Together
   Students head together to illustrate and ensure that each person knows the answer.
d. Step 4: Answering

The teacher mentions a number, and students of each group with the same number raise his hand and prepare the answer for all.

1.4. Problem-solving Ability

Ability comes from *able*. According to Indonesian Most Complete Official Dictionary (KBBI), able means having power (capable) to do something. Yunarti et al. (2013: 128) defines ability as someone's power to give his maximum potential about something. Hence, the ability is someone's power/ capability to do something.

The problem which in Indonesia is called *masalah* comes from Arabian, meanwhile in Greek and Latin called a *problem, question* (question). Komarudin et al. (Wakhyudin & Juliyati, 2014: 4) say that problem means a source of confusion that is complicated and bothering or difficulties that are needed to be solved. Thus, the problem is a difficult thing that leads to a confusion that is urgently needed to solve.

Further, Polya (Amir, 2009: 45) says that problem-solving ability is a process to overcome and solve a problem faced until it is gone or becomes nothing. Gagne (Amir, 2009: 45) defines problem-solving ability as a set of procedures or strategies that possibly enable someone to increase his independence in thinking. In brief, the problem-solving ability is someone's ability to overcome a problem and apply it in his daily life.

In addition, Polya (Wardhani, 2010) divides four aspects of problem-solving ability, as follows:

a. Understanding the problem
   This aspect involves understanding or deepening problem situations, sorting the facts, determining the relation between facts, and formulating problem questions. Every problem, even the easiest one, is required to repeatedly read (both written or not) as well as the information on the problem is requires to be carefully studied.
b. Making problem-solving plans
   The solution plan is arranged to consider the problem structure and question that must be answered. In the problem-solving process, students are organized to have experience in applying various problem-solving strategies.
c. Performing problem-solving plans
   The plan made must be carefully done to find out an appropriate solution. Diagrams, tables, or sequences are carefully constructed so that students (problem solver) will not be confused. If inconsistencies arise when carrying the plans out, the process must be reviewed to find the source of problem difficulties.
d. Looking (rechecking)
   During the process of this step, the problem's solution must be considered. The solution must be appropriate toward the core of problems, although it seems unreasonable.

2. Methods

2.1. Research Design

This study was Quasi-Experimental Design research with Non-Equivalent Control Group Design. It is illustrated on the Figure 1.

O_1	X	O_2
O_3		O_4

Figure 1. Research Design (Source: Sugiyono, 2017: 79)

Notes:
O_1: Pretest of experimental class
O_2: Posttest of experimental class
O_3: Pretest of the control class
O_4: Posttest of the control class
X: Treatment by using NHT cooperative learning model

In this design, the experimental class was specially treated by using a cooperative learning model with NHT during the learning process. Meanwhile, the control class was treated by using the conventional learning model. Pretest and posttest were given to both classes to find out the result before and after the treatment given.

Further, this study was conducted in August 2019 in SMP N 5 Salatiga. The population of this study was VII grade students of SMP N 5 Salatiga in the academic year 2019/ 2020. This study used a purposive sampling technique. It was conducted by many consideration (Sugiyono, 2017: 81-81). The researchers also involved teacher's opinion (Mrs. Mumtanikhah, S.Pd as Mathematics teacher) in choosing VII G as the control class and VII H as the experimental class considering that both classes had the same ability. Additionally, this study consisted of an independent variable, namely cooperative learning with NHT type and dependent variable, namely mathematical problem-solving ability.

3. Results & Discussions

3.1. Pre-test

Based on the research result, the pre-test result of experimental and control classes can be seen in Table 2.

Table 2. The Recapitulation of Pre-test Result

Notes	Pre-test	
	Experimental Class	Control Class
The average score	43.98	41.39
The highest score	63.75	80.00
The lowest score	22.50	25.00

Based on the table above, the pre-test average of the experimental class was 43.98, and the control class was 41.39. Further, the data on table 3 were analyzed by using IBM PSS Statistic 25.0 for windows program to examine the normality of data. Then the result of the pre-test normality test of experimental and control classes is presented in Table 3.

Table 3. The Recapitulation of Pre-test Normality Test

Class	Significant Level	Conclusion
Experimental	0.200	Normally distributed
Control	0.016	Not normally distributed

As seen in Table 3, the pre-test normality test results with a confidence level of 5% (α 0.05) were sig. level (2-tailed) for the experimental class was 0.200 > 0.05, so H_0 was accepted, and H_1 was rejected. It means that the pre-test of the experimental class was normally distributed. Meanwhile, sig. value (2-tailed) of the control class was 0.016 < 0.05, so H_0 was rejected, and H_1 was accepted. It means that the pre-test of the control class was not normally distributed.

Furthermore, the homogeneity test by using Levine Test was conducted to determine the homogeneity sample. The results of this test are presented in Table 4.

Table 4. The Recapitulation of Pre-test Homogeneity Test Result

Pre-test Result	Levene's Statistic	df1	df2	Sig.
Based on mean	0.043	1	60	0.837

Based on Table 4, the significance value was 0.837 > 0.05, so H_0 was accepted, and H_1 was rejected. In other words, there was no variance, or the data were homogeneous.

As the data were not normal and homogeneous, the comparative hypothesis test was conducted by using the Mann Whitney U test. This test was performed to find out whether the data were significant or not. The value obtained from this test was sig. (2-tailed) which then was compared to the confidence level of 5% (α 0.05). If sig. (2-tailed) > 0.05, the data were different and significant, and if sig. (2-tailed) < 0.05, so the data were not different and insignificant. The results of Mann Whitney U of pre-test data can be seen in Table 5.

Table 5. Pre-test Mann Whitney Test

Pre-test		Sig. (2-tailed)	Conclusion
Mathematical Ability	Problem-solving	0.278	H_0 is accepted

Table 5 shows that sig. value (2-tailed) of experimental and control classes were 0.278 with a confidence level of 5% (α 0.05), so H_0 was accepted while H_1 was rejected. This result shows that there was no difference in the average of students' mathematical problem-solving between both classes; either experimental and control classes' were the same.

3.2. Post-test

The results of the post-test of experimental and control classes are presented in Table 6.

Table 6. The Recapitulation of Post-test Result

Keterangan	*Post-test*	
	Experimental	Control
Average	73.24	58.62
Highest Value	96.25	82.50
Lowest Value	43.73	37.50

Based on Table 6, the post-test average of the experimental class was 73.24, and the control class was 58.62. These data were then analyzed by using IBM SPSS Statistic 25.0 for windows program to test the normality of data. The results of the normality test can be seen in Table 7.

Table 7. Recapitulation of Post-test Normality Test Result

Class	Significant Level	Conclusion
Experimental	0.000	Not normally distributed
Control	0.144	Normally distributed

Based on Table 7, post-test normality test results with a confidence level of 5% (α 0.05) were sig. value (2-tailed) of the experimental class was 0.000 < 0.05, so H_0 was rejected, and H_1 was accepted. It means the post-test data of the experimental class were not normally distributed. Meanwhile sig. value (2-tailed) of the control class was 0.144 > 0.05, so H_0 was accepted while H_1 was rejected. In other words, post-test data of control class were normally distributed.

Normality and homogeneity tests are different. A homogeneity test is conducted to test the differences between different subjects of several groups. This study used Levine Test for determining the homogeneous sample. The results of the homogeneity test of experimental and control classes' post-test are presented on Table 8.

Table 8. The Recapitulation of Post-test Homogeneity Test Result

Post-test Result	Levene's Statistic	df1	df2	Sig.
Based on mean	0.368	1	60	0.546

Table 8 shows that sig. value was 0.546 > 0.05, so H_0 was accepted, and H_1 was rejected, it means that there was no difference invariance or the data were homogeneous.

Since the data were not normal and homogeneous, a comparative hypothesis test was performed by using the Mann Whitney U test. This test was conducted to find out whether the data were significantly different or not. This test resulted in significant value (2-tailed), which is then compared to a confidence level of 5% (0.05). If sig. value (2-tailed) > 0.05, so the data were significantly different, if sig. value (2-tailed) < 0.05, so the data were insignificantly different. The result of the Mann Whitney U test of post-test data is shown in the Table 9.

Table 9. Mann Whitney U Test of Post-test Data

Post-test	Sig. (2-tailed)	Conclusion
Mathematical Problem-solving Ability	0.00	H_0 is rejected

Table 9 shows that sig. value (2-tailed) of experimental and control class was 0.00 with a confidence level of 5% (0.05), so H_0 as rejected, and H_1 was accepted. In brief, there was no differences in students' mathematical problem-solving ability on both classes.

3.3. N-Gain

The results of the N-gain test of experimental and control classes can be seen in Table 10.

Table 10. The Result of N-Gain Test of Students' Mathematical Problem-solving Ability

Score	Experimental Class	Control Class
$g \geq 0.7$	5	1
$0.3 \leq g$ 0.7	25	17
$g < 0.3$	2	12
Average	0.54	0.29

Based on Table 10, the average N-gain score of the experimental class was 0.54; particularly, five students' mathematical problem-solving ability had increased in the high category, 25 students' with medium category, and five students with a low category. Meanwhile, the N-gain score of control class was 0.29, 1 students' mathematical problem-solving ability had increased in the high category, 17 students' with medium category, and 12 students with a low category.

The data then analyzed using normality, homogeneity, and further tests. If the data were normally distributed and homogeneous, a comparative hypothesis by using parametric statistics (t-test) would be performed, but if the data were not normally distributed and homogeneous, so non-parametric statistics by using Mann Whitney U test would be performed.

Table 11 shows the result of the N-gain normality test of both classes.

Table 11. The Result of Normality Test of N-gain Data

N-Gain	Significant Level	Conclusion
Experimental Class	0.001	Not normally distributed
Control Class	0.050	Not normally distributed

Table 11 shows that the N-gain normality test result with a confident level of 5% (0.05) that was sig. value (2-tailed) of experimental class 0.001 < 0.05, so H_0 was rejected, and H_1 was accepted. It means that N-gain data of the experimental class were not normally distributed. Meanwhile sig. value (2-tailed) of the control class was 0.05 = 0.05, so H_0 was rejected, and H_1 was accepted. In other words, N-gain data of control class were not normally distributed.

Subsequently, the homogeneity test of N-gain data was conducted. The results are presented in the Table 12.

Table 12. The Recapitulation of Homogeneity Test 0f N-gain Data

N-Gain Result	*Levene's Statistic*	df1	df2	Sig.
Based on mean	0.136	1	60	0.714

As seen in Table 12, the significant value was 0.714 > 0.05, so H_0 was accepted, and H_1 was rejected. It means that the variance was not different, or the data were homogeneous.

As for the data were not normal and homogeneous, comparative hypothesis test with the Mann Whitney U test was conducted. It was used to observe whether the data were significantly different or not. This test resulted in sig. value (2-tailed), which was then compared with a confidence level of 5% (0.05). If sig. value (2-tailed) > 0.05, so the data were significantly different, while if Sig. value (2-tailed) < 0.05, the data were insignificantly different. The following table presents the result of the Mann Whitney U test of N-gain data.

Table 13. Mann Whitney U Test of N-gain Data

N-Gain	Sig. (2-*tailed*)	Conclusion
Mathematical Problem-solving Ability	0.00	H_0 is rejected

Based on Table 13, sig. value (2-tailed) of both classes was 0.00 with confidence level 5% (0.05), so H_0 was rejected, and H_1 was accepted. It means that there were differences in the increase of students' mathematical problem-solving ability of experimental and control classes.

This condition happened because the experimental class was specially treated with a cooperative learning model with the NHT model; therefore, students' mathematical problem-solving ability of this class could successfully increase. In this learning model, students were required to actively get involved in learning activities, including the discussion process, which attracted students' mathematical problem-solving ability continuously increased. Forasmuch as students did not only have their own answers, yet all of the students in a group had to discuss to obtain correct problem-solving. Additionally, the random calling process made students became always get ready whenever they would be called to give a presentation. Consequently, they would always try to understand the answers discussed in the group.

4. Conclusion

The results show that there are differences in the average of students' mathematical problem-solving ability in mathematics learning between the classes used cooperative learning in VII grade students of SMP Negeri 5 Salatiga in the academic year 2019/ 2020. Likewise, the results also show that there are differences in the increase of students' mathematical problem-solving ability in mathematics learning between the classes used cooperative learning with NHT type and conventional models in students.

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