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Mathematical problem-solving ability: The effect of numbered head together (NHT) model and mathematical prior knowledge

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Abstract

This study aimed to determine the effect of the NHT (Numbered Head Together) cooperative learning model on mathematical problem-solving abilities in terms of students' mathematical prior knowledge. The researchers employed quasi-experimental research and collected the mathematical problem-solving data using a description test. At the same time, the researchers investigated students' mathematical prior knowledge using the mid-semester examination (UTS) scores. The hypothesis was tested using the two-way ANOVA with unequal cells. The results showed that the NHT learning model provided better problem-solving skills than the direct learning model. The category of students' prior knowledge also affected their mathematical problem-solving abilities. Therefore, teachers should pay attention to the prior knowledge possessed by students so that an appropriate learning model can be selected.

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INTRODUCTION

In studying mathematics, students are required to memorize formulas and take benefit from mathematics. The usefulness of the mathematics learning process can be seen with an awareness of what is being done, what is understood, and what is not understood by students (Putra, 2017). One of the important abilities in learning mathematics is mathematical problem-solving (Wulandari et al., 2016). Through problem-solving, students solve problems and interpret them (Nengsih et al., 2018). Therefore, problem-solving is beneficial for students to have the ability to think, reason, predict, find solutions to the problems, and prove the truth so that students' mathematical problem-solving abilities can continue to develop. Also, mathematical problem-solving is hoped to help students to understand the problem (understanding the problem), plan a solution (devising a plan), carry out the solution according to the plan that has been made (carrying out the plan), and re-examine the results that have been obtained (looking back) (Pramesti & Rini, 2019).

In solving a mathematical problem, mathematical prior knowledge is also needed to help and facilitate students. Mathematical prior knowledge is important as mathematical knowledge or experience supports further mastery of mathematical material or solves similar mathematical problems (Kadir, 2017; Pamungkas et al., 2017).

Based on the interview with one of the mathematics teachers at SMP N 1 Bandar Lampung, the teacher was still using the direct learning model. In this learning model, the teacher is more active in conveying information, while the role of students is only to listen and record important things from the explanations. In this learning, the contribution of students in learning is minimum. The teacher also used group discussions during their learning. However, the results were not better than before. In determining the discussion group, the teacher allowed the students to freely choose the group members. This freedom made the students choose classmates with who they were familiar. Ultimately, it encouraged students to chat with their peers rather than discuss the learning material. Thus, the teacher rarely employed group discussions in the learning process and utilized the direct learning model. This phenomenon resulted in low mathematics learning outcomes.

Based on the interviews with the teachers, the students' mathematical problem-solving abilities were still low. When the students were faced with problem-solving-based questions, they rarely wrote

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down what they knew. More of them immediately seek the answers to the questions. After getting the answers to the problems, they did not correct them again to find out whether the answers they got were correct.

The cooperative learning model is one of the learning models in which students are grouped into small group members with different levels of ability and work together on structured tasks. Its characteristics are team learning, cooperative management, working together, and teamwork skills (Abdullah, 2017; Hasanah, 2021; Suparmi, 2012). One of the cooperative learning models used in learning mathematics is the Numbered Head Together (NHT). NHT can help students to understand and master the concept of learning mathematics and also increase cooperation between students, where each student is given a number and has the same opportunity to answer the problems posed by the teacher through random number calling (Lestari & Yudhanegara, 2015; Muliandari, 2019). The NHT cooperative learning model emphasizes students work together in groups. Each member in the group can master and understand the results of the discussion and be responsible for the results of their group work (Riansyah et al., 2020).

NHT learning model has been widely carried out in several previous studies (Kusuma & Maskuroh, 2018; Maman & Rajab, 2016; Mustami & Safitri, 2018; Pratiwi, 2019; Sutipnyo & Mosik, 2018). Mustami & Safitri (2018) state that the NHT strategy affects students' motivation. Furthermore, Maman & Rajab (2016) mention that the NHT learning model affects reading ability. Research by Kusuma & Maskuroh (2018) mentions that the NHT model influences cognitive abilities compared to the Think Pair Share (TPS) model. However, in this research, the cognitive abilities were focused on the students' mathematical problem-solving abilities. Based on this research, NHT learning was expected to positively impact learning outcomes. Furthermore, no researcher has discussed its impact on mathematical problem-solving abilities in terms of students' mathematical prior knowledge. Therefore, the purpose of this research was to determine the effect of the NHT learning model on mathematical problem-solving abilities in terms of students' mathematical prior knowledge at SMP Negeri 1 Bandar Lampung.

METHOD

This research was quantitative-experimental, specifically quasi-experiment research. The method was chosen because the researchers could not control the external variables that may affect the studied variables, and it was impossible to strictly group respondents. In this study, the respondents were grouped into two groups. The first group was the experimental group, namely students who received mathematics learning treatment with the NHT cooperative learning model. The second group was the control group, namely students who received mathematics learning treatment with a direct learning model. Besides, external factors examined in this research affected mathematical problem-solving abilities, namely students' mathematical prior knowledge. The research design was a 2 x 3 factorial, as displayed in Table 1.

Table 1. Research Design

Learning Model \ Mathematical Prior Knowledge	High (β_1)	Medium (β_2)	Low (β_3)
NHT (α_1)	$\alpha_1\beta_1$	$\alpha_1\beta_2$	$\alpha_1\beta_3$
Direct Instruction (α_2)	$\alpha_2\beta_1$	$\alpha_2\beta_2$	$\alpha_2\beta_3$

The research population was all ninth-grade students of SMP Negeri 1 Bandar Lampung, which consists of six classes. The researchers employed the cluster random sampling technique. The data collection technique used was a mathematical problem-solving ability test. The researchers performed the normality test using the Lilliefors formula and the Bartlett test's homogeneity test. The hypothesis was tested using the two-way ANOVA test with unequal cells.

The following is a flow chart of the research methods applied in this research.

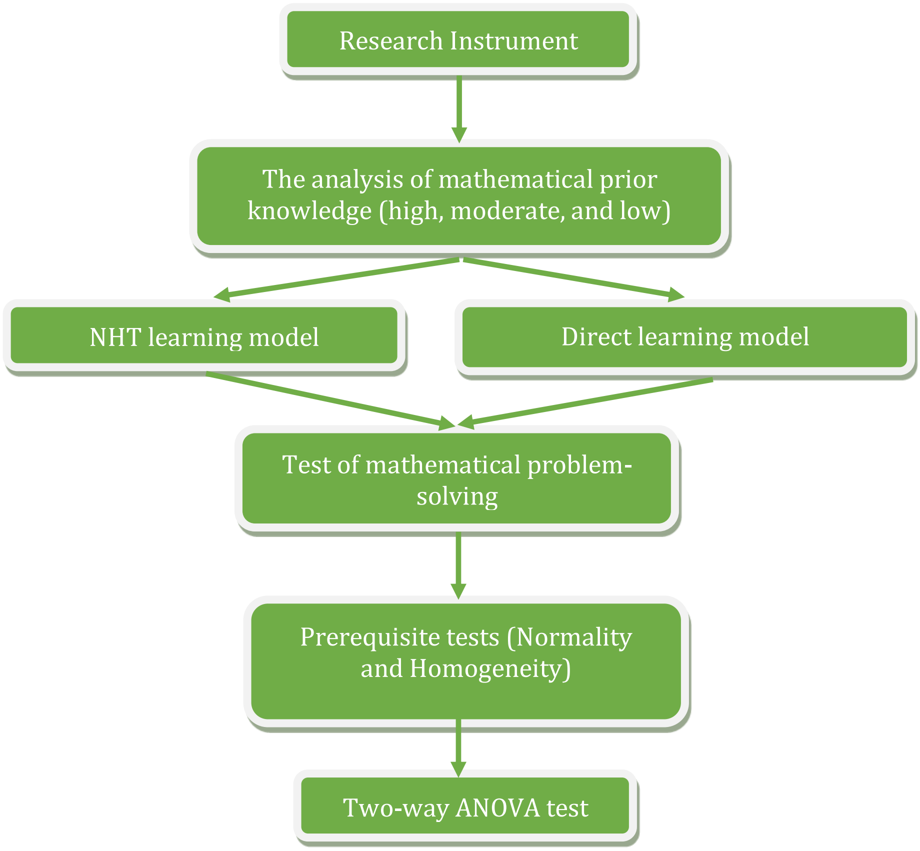

Figure 1. The Research Methods.

RESULTS and DISCUSSION

Before testing the hypothesis, it was necessary to perform the prerequisite tests. Based on the normality test calculation results on mathematical problem-solving abilities, the experimental class obtained $L_{observed}$ **=** 0.142 and $L_{critical}$ = 0.159. The control class obtained $L_{observed}$ **=** 0.142 and $L_{critical}$ = 0.159. Based on these calculations, $L_{observed} \leq L_{critical}$ with a significance level (α) of 0.5. Therefore, H_0 was accepted, and it can be concluded that the sample came from a normally distributed population.

Based on the calculation of the homogeneity test of mathematical problem-solving abilities, it is known that $\chi^2_{observed} \leq \chi^2_{critical}$ where $\chi^2_{observed}$ = 0.291 and $\chi^2_{critical}$ = 3.84 with a significance level (α) of 0.5. Therefore, H_0 was accepted, and it can be concluded that the two samples came from the same population (homogeneous).

The following summarizes the average and marginal mean of students' mathematical problem-solving abilities.

Table 2. The Marginal Means and Averages of Mathematical Problem-Solving Ability

Learning Model	Mathematical Prior Knowledge			Marginal Average
	High	Moderate	Low	
NHT Learning Model	93.64	80.14	67.02	78.29
Direct Learning Model	85.96	71.45	53.86	67.19
Marginal Mean	89.8	75.80	60.44	

Based on the analysis, the mathematical problem-solving ability data were normally distributed and homogeneous so that the researchers could perform the hypothesis test using the two-way ANOVA of an unequal cell. The following table summarizes the two-way ANOVA of unequal cells.

Table 3. The Summary of Two-Way ANOVA

Source	JK	Dk	RK	$F_{observed}$	$F_{critical}$
Learning Model (A)	56,659	1	56,659 4,573	4.00	PAM
(B)	3551,831	2	1775,916	143,343	3,15
Interaction	4,979	2	2,489	0.201	3.15
Error	768.134	62	12.389		
Total	4381.604	67			

Based on Table 3, the $F_{A\ observed} \geq F_{A\ critical}$ where $F_{A\ observed}$ = 4.573 and $F_{A\ critical}$ = 4.00. Therefore, H_{0A} was rejected, and it can be concluded that there was a difference between students who received the NHT learning model and the direct learning model in terms of mathematical problem-solving abilities. Based on Table 2, students who received the NHT learning model treatment had an average score of 78.29, while students who received the direct learning model treatment had an average score of 67.19. Therefore, the students who received the treatment of the NHT learning model were better than the students who received the direct learning model in terms of mathematical problem-solving abilities.

Based on Table 3, $F_{B\ observed} \geq F_{B\ critical}$ where $F_{B\ observed}$ = 143,343 and $F_{B\ critical}$ = 3,15. Therefore, H_{0B} was rejected, and it can be concluded that there was a difference between students with high, moderate, and low mathematical prior knowledge in terms of mathematical problem-solving abilities. To find out which prior knowledge significantly influences mathematical problem-solving abilities, it was necessary to perform the Scheffe test.

Table 4. The Multiple Comparison Between Column Test

Interaction	$F_{observed}$	$F_{critical}$	Decision
μ_1 vs. μ_2	102,942	6,3	H_0 is rejected
μ_1 vs. μ_3	341,812	6.3	H_0 is rejected
μ_2 vs. μ_3	87,576	6,3	H_0 is rejected

Based on Table 4, for μ_1 vs μ_2, $F_{observed}$ = 102,942 and $F_{critical}$ = 6.3. Therefore, hypothesis 0 (H_0) was rejected. It means that there was a significant difference between students with high and moderate mathematical prior knowledge toward mathematical problem-solving ability. For μ_1 vs μ_3, $F_{observed}$ = 341.812 and $F_{critical}$ = 6.3. Therefore, H_0 was rejected. In conclusion, there was a significant difference between students with high and low mathematical prior knowledge toward mathematical problem-solving ability. For μ_2 vs μ_3 , $F_{observed}$ = 87.576 and $F_{critical}$ = 6.3. Therefore, H_0 was rejected. In short, there was a significant difference between students with low and moderate mathematical prior knowledge in terms of mathematical problem-solving abilities.

Based on Table 2, the marginal mean for students with high mathematical prior knowledge was 89.80, students with moderate mathematical prior knowledge were 75.80, and students with low mathematical prior knowledge were 60.44. Therefore, students with high mathematical prior knowledge were better than those with moderate and low. Furthermore, students with moderate mathematical prior knowledge were better than students with low mathematical prior knowledge in mathematical problem-solving abilities.

Based on Table 3, $F_{AB\ observed} < F_{AB\ critical}$ where $F_{AB\ observed}$ = 0.201 and $F_{AB\ critical}$ = 3.15. Therefore, H_{0AB} was accepted, and it can be concluded that there was no interaction between the learning model and students' mathematical prior knowledge in terms of mathematical problem-solving abilities. Based on the analysis, the mathematical problem-solving abilities of students treated with the NHT cooperative learning model were better than those treated with the direct learning model. In the NHT cooperative learning model, each student in the group was actively involved in discussions to solve problems. After the group discussion had been completed, the teacher mentioned a number at random, and students with the same number came forward to present their groups' answers so that each student had the same opportunity to be selected. This causes each student to answer each problem. By working in groups, students can be assisted when they have difficulties. Individually, students understood each problem because they felt that they would be chosen to present the discussion results and would feel embarrassed if they could not answer the problems. In presentations, the students conveyed the results of their group discussions, and other students paid attention to the presentation and provided feedback. With the teacher's guidance, the class discussion was intended to equalize the understanding of students between different groups. Through class discussions, learning became more active because of the interaction among students and between students and teachers. Thus, the NHT type cooperative learning model can be used to improve students' mathematical problem-solving abilities.

The results of this study are in line with research by Erawati et al (2021) that the NHT learning model has a positive effect on students' mathematical problem-solving abilities, where the NHT learning model is better than the expository learning model at SMP Negeri 9 Serang City. The results of this research are also in line with research carried out by Riansyah et al (2020). They found that the NHT learning model influences mathematical problem-solving abilities of the eighth-grade students of MTs Unwanul Falah Kupang Rejo Pesawaran Regency in the 2019/2020 Academic Year. The class treated with the NHT learning model had a higher level of mathematical problem-solving ability than the class that was given conventional learning. Therefore, students treated with the NHT cooperative learning model are better than those treated with the expository, conventional, and direct learning models.

Based on the analysis, students with high mathematical prior knowledge were better than students with medium and low mathematical prior knowledge. Also, students with moderate mathematical prior knowledge were better than students with low mathematical prior knowledge. It was very clear that students with high mathematical prior knowledge were more active during the learning. They were enthusiastic when conducting an experiment from the material provided and solving existing problems. Students with moderate mathematical prior knowledge asked other students when they had difficulties. However, the results were not optimal. Students with low mathematical prior knowledge looked passive during learning. When they faced difficult problems, only a few students asked other students, and more students chose to be silent and waited for answers from other students. This phenomenon influenced high, medium, and low mathematical prior knowledge on mathematical problem-solving abilities.

The research results align with the research carried out by Pamungkas et al., (2017) that students with high mathematical prior knowledge are better than students with moderate and low mathematical prior knowledge on the mathematical, logical thinking ability at the Science Study Program of FKIP Sultan Ageng Tirtayasa University. The results of this research are also in line with the research conducted by Aini (2018) that there are significant differences between students with high, medium, and low mathematical prior knowledge on mathematical creative thinking abilities at SMPN 2 Karawang Timur. Therefore, students' mathematical prior knowledge affects mathematical, logical thinking skills, mathematical creative thinking skills, and students' mathematical problem-solving abilities.

CONCLUSION

Based on the analysis and hypothesis testing results, there was an influence between students receiving the NHT treatment and students receiving the direct learning model on mathematical problem-solving abilities. Also, there was an influence between students with high, medium, and low mathematical prior knowledge on mathematical problem-solving abilities. Furthermore, there was no interaction between the learning model and students' mathematical prior knowledge on mathematical problem-solving abilities.

This research had several limitations; namely, the material used was only the curved side of solid geometry, and the cognitive abilities studied were mathematical problem-solving abilities. Therefore, further research can involve other materials and other mathematical cognitive abilities. This research can be used as a reference for other research.

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