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THE EFFECT OF POLYA'S HEURISTIC STRATEGY ON STUDENTS MATHEMATICAL LITERACY ABILITY

M. Iqbal Al-Ihsan[1], Titis Wulandari[2*], Oktavian Dwi Prasetyo[3] Chindi Yuliana[4]

[1,2*,3,4] Universitas Muhammadiyah Muara Bungo, Bungo, Indonesia
**Corresponding author.*
E-mail: *Muhaiqbalihsan@gmail.com[1)]*
Titiswulandari17@gmail.com[2)]*
Oktaviandwiprasetyo53@gmail.com[3)]
chindi1561@gmail.com[4)]

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Abstract

Mathematics is a field of study taught in elementary schools, considered by some students to be difficult to understand. This is because the way of implementing learning is required to be limited to definitions, understanding how to solve problems and operate mathematics correctly. So it is necessary to implement efficient and interesting learning for students, so that students understand the concept of mathematics learning, especially mathematical literacy, through a problem-based learning model with a polya heuristic strategy. This research aims to determine the application of the polya heuristic strategy to students' mathematical literacy problem solving abilities. This research uses a quantitative approach with a quasi-experiment research method and the research subjects are elementary school students with a population of 80 students. The sampling technique was carried out using cluster random sampling of 50 students, with a two group pretest-posttest design in the form of a control class by providing conventional method classes. and experiments by applying heuristic strategies and analyzed using statistical tests, namely Validity, Reliability, Differentiating Power and Question Difficulty Levels. Based on the results of research on statistical tests for normality tests, the data was not normally distributed (Þ = <0.001), therefore, the Wilcoxon test was carried out in the next stage. Based on the test results, significant differences were obtained between the pretest and posttest results. The average pretest result for the control class was 49.6 and the experimental class 47. Then after being given treatment, the average posttest score for the control class became 54.8 (conventional method) while the experimental class became 67.6 (polya heuristic strategy). Judging from the posttest scores, both classes showed an increase in learning outcomes, but a large increase was seen in the experimental class where the polya heuristic strategy was applied. This research is useful in making a contribution to mathematics learning, especially in improving the quality of the cognitive aspects of mathematics literacy using the Polya Heuristic strategy. The polya heuristic strategy has an impact on increasing students' mathematical literacy, therefore this strategy can be implemented in mathematics learning at various levels of education.

Keywords: Mathematical literacy; Polya heuristics; problem solving.

Abstrak

Matematika merupakan bidang studi yang diajarkan disekolah dasar, dianggap oleh sebagian siswa sulit dipahami. Hal ini disebabkan cara penerapan pembelajaran dituntut hanya sebatas definisi, pengertian cara pemecahan masalah maupun pengoprasian matematikan secara benar. sehingga perlu penerapan pembelajaran yang efesien dan menarik untuk siswa, agar peserta didik memahami konsep pembelajaran matematika khususnya literasi matematika, melalui model pembelajaran berbasis masalah dengan strategi heuristic polya. Penelitian ini bertujuan untuk mengetahui penerapan strategi heuristik polya terhadap kemampuan pemecahan masalah literasi matematika siswa. Penelitian ini menggunakan pendekatan kuantitatif dengan metode penelitian quasi-experiment dan subjek penelitian siswa SD dengan populasi sebanyak 80 siswa, Teknik pengambilan sampel dilakukan secara cluster random sampling sebanyak 50 siswa, dengan desain two group pretest-posttest design berupa kelas kontrol dengan memberikan kelas metode konvensional dan eksperimen dengan penerapan strategi heuristik dan

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dianalisis menggunakan uji statistic yaitu Uji Validitas, Reliabilitas, Daya Pembeda, dan Tingkat Kesukaran Soal. Berdasarkan hasil penelitian pada uji statistik uji normalitas data berdistribusi tidak normal (Þ =<0.001) maka dari itu, tahap selanjutnya dilakukan uji wilcoxon. Berdasarkan hasil uji tersebut diperoleh hasil perbedaan yang signifikan antara hasil pretest dan posttest. Rata-rata hasil pretest kelas kontrol adalah 49.6 dan kelas eksperimen 47. Kemudian setelah diberikan perlakuan, rata-rata nilai posttest kelas kontrol menjadi 54.8 (metode konvensional) sedangkan kelas eksperimen menjadi 67.6 (strategi heuristik polya). Dilihat pada nilai posttest tersebut kedua kelas menunjukkan peningkatan hasil belajar, akan tetapi peningkatan yang besar terlihat pada kelas eksperimen yang diterapkan strategi heuristik polya. Penelitian ini bermanfaat dalam memberikan kontribusi dalam pembelajaran matematika, khususnya dalam rangka meningkatkan kualitas aspek kognitif literasi matematika dengan strategi Heuristik Polya. Strategi heuristik polya berpegaruh terhadap peningkatan literasi matematika siswa, oleh karena itu strategi ini bisa diimplementasikan dalam pembelajaran matematika diberbagai tingkat Pendidikan.

***Kata kunci**: Literasi matematika; Heuristik polya; pemecahan masalah.*

INTRODUCTION

Education should aim to educate students so that they construct their own knowledge, not just memorize the concepts given by the teacher. As a result, students can have high-level thinking skills, such as self-regulation strategies, critical thinking, problem solving, metacognitive thinking, and others. The role of education in creating quality and potential human resources (HR) is very important, because it has a direct effect on producing quality human resources through the educational process carried out in schools in the form of learning activities. One of them is learning mathematics. Basically mathematics education is categorized as factual knowledge based on abstract and conceptual principles. This is what causes many students to experience difficulties in interpreting mathematical ideas and thoughts into the real world as a whole. Mathematics is a science that relates or examines abstract forms or structures and the relationships between those things (Umam, Nurlaelah, 2020).

Mathematics, which was previously considered abstract, becomes a direct challenge for students in identifying numbers, formulas, sentences, and symbols because they are related to life situations and offer direct benefits in everyday life to be represented more concretely (Sari & Wijaya, 2017). As a result, students have difficulty learning the concept of mathematical material as a whole, so that students tend to memorize and work on mathematical problems not based on the correct process. If this problem is left unchecked, students will become less active when learning mathematics takes place. Therefore, a special approach is needed to make it easier for students to solve existing problems. In conclusion, the approaches and strategies applied by educators greatly affect the ability of students to solve mathematical problems even if the questions are considered difficult (Ozturk & Guven, 2016). The mathematics learning objectives implemented by (Joung & Byun, 2021), (contain five competencies, namely mathematical problem solving, mathematical communication, mathematical reasoning, mathematical connections and mathematical representation).

NCTM formulated five competency categories that can be expressed in mathematical literacy.

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Through the Polya Heuristic Strategy, it is hoped that students will be able to explain processes, reflect, and ultimately develop flexible thinking and skills so that they can be used in problem solving situations (Wulandari et al., 2012). Mathematical literacy can be defined as an individual's ability to formulate mathematics, apply and interpret mathematics in various contexts (Aminah et al., 2019). Study by (Tasekeb et al., 2019), with the MEA learning model with a scientific approach related to mathematical literacy skills. The same research was conducted by (Darma & Sujadi, 2014), The use of the polya heuristic method is only for mathematical problem solving abilities. This research aims to determine the application of the polya heuristic strategy to students' mathematical literacy problem solving abilities. Literacy in this case actually helps each individual to be able to think and reason and examine existing problems in a structured and systematic manner so as to arrive at a decision-making process.

Problems in mathematics are story problems that do not have certain rules to be solved immediately (Tambunan, 2020). Based on the results of interviews with mathematics teachers at SDN 95 Bungo, it was found that the problem was that students were still unable to distinguish between questions and statements in the questions, this was due to the students' lack of literacy skills, so it was hoped that this research could provide a solution to this problem and be used as a reference for reform learning.

METHODS

This research uses a quantitative approach with a quasi-experimental research design, namely by applying a polya heuristic (sustainable) strategy (Lestari & Aisah, 2019). The research design can be seen in Figure 1.

$$(O_1) \rightarrow E_1 \rightarrow X \rightarrow O_2$$
$$(O_1) \rightarrow E_2 \rightarrow - \rightarrow O_2$$

Figure 1. Research Design

Information:
E1 : Experiment
E2 : Control
O1 : Class pretest
O2 : Class posttest
X : Treatment with a heuristic strategy
- : No treatment

O2 techniques for collecting data use a test method with 5 essay questions for the test. The test is used to measure students' level of mastery of the concept of the material. The instrument used is a test: pre-test and post-test questions. Once the research instrument (test) has been prepared, it must be tried out before being tested. To find out whether the instrument is good, you must know the analysis of validity, reliability, level of difficulty of the questions and the differentiating power of the questions.

The subjects of this research were class VI students at SDN 095/II Muara Bungo with a population of 75 people. The sampling technique is purposive sampling so that the sample is determined by the researcher. with research objectives namely VI A (25 students) as the control class and VI C (25 students) as the experimental class. This research consisted of a control class using conventional methods, while the experimental class using the polya heuristic strategy method consisted of 14 male students and 11 female students with an average of 10-11 years of age. Research activities that provide an initial test (pretest) to determine students' initial abilities. before being

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given treatment, after being given treatment then given a final test or posttest (Aslami et al., 2019).

The research has taken a sample of Class V for the following reasons: (1) in this school there are two classes, (2) the number of both classes is the same, (3) students in classes VIA and VIC have normal data distribution, this is the first ability theory or tested with previous normality tests. (4) VIA and VIC class students show similar variance and (5) the 2013 syllabus is used for learning. The research process was carried out through implementation based on heuristic poly strategy steps which took place during 1 meeting. The first step is related to the orientation of the problem. Students are directed to identify the syntax problem of literacy in Table 1.

Table 1. Literacy syntax research instrument grid

No	Literacy Aspects	Mathematics
1	Definition	Individual capacity to formulate, apply and interpret mathematics in various contexts. The ability to recognize and understand the role of mathematics in the world, to serve as a basis for using and engaging with mathematics in accordance with students' needs as constructive, caring and reflective citizens.
2	Content Dimensions	Number (Quantity); Space and shape (Space and shape); Change and relationships (Change and Relationship); Probability/uncertainty (Uncertainty).
3	Process Dimensions	Formulate the situation mathematically; Applying concepts, facts, procedures, mathematical reasoning; Interpret, apply and evaluate mathematical results.
4	Context Dimensions	Personal; Work; Public; and Scientific.

In the second step, namely orientation to the problem in the form of students looking for an initial idea of the material regarding Numbers (Quantity); Space and shape (Space and shape);. through teacher direction by formulating the situation mathematic-cally. Data collection techniques in this research are carried out through thesis techniques. Thesis technique is carried out by providing evaluation questions carried out by students. The questions used are in the form of descriptions consisting of 5 essays to measure literacy skills (Narbuko & Achmadi, 2017). The instrument is balanced through a validity test and discussed together with fellow colleagues.

Before the theis is assigned to the class that is the sample of the study, the thesis questions are tried out first in classes VI and IISDN 4 Bungo which have the same school accreditation as the sample of the study. The questions provided are in the form of 5 essay questions. The next stage is to carry out feasibility tests which include tests of validity, reliability and normality. From this process, 5 questions were obtained which met the criteria and were worthy of being used as questions to collect data.

Data analysis techniques use statistical tests, namely normality tests and hypothesis tests with the help of SPSS 22 for Windows with sig. 0.05.

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The data analyzed were the results of the control class posttest and experimental mixed arithmetic operations material.

RESULTS AND DISCUSSION

Many students have not been able to distinguish between statements and questions in the given story problems. As a result, students cannot plan problem solving according to the process. Therefore, to avoid this from happening the researcher compiled a schedule of effective learning activities including initial, core and final activities. In the initial activity, the teacher conveys the learning objectives to be achieved as a reference for students. In the core activities, the teacher provides learning materials using the polya heuristic strategy as an effort to increase students' potential in learning Mathematics. In the final activity, the teacher reflects on students' understanding of the material well so that they are able to complete the test, namely the posttest at the end of the study. This research is said to be valid if the instruments used can measure what is to be measured. A validity can be known after the instrument trial activities are carried out. The researcher gave a posttest to students at the end of the study in the form of five essay questions with C2 and C3 difficulty levels to measure students' cognitive abilities on the material that had been taught. This measurement was carried out in both classes before and after the treatment. The learning outcomes that have been implemented can be seen in Table 2.

Table 2. Student learning outcomes

Class	Pretest	Posttest
Control	49.6	54.8
Experiment	47	67.6

Table 2 describes the average value obtained from the pretest results for the control class, which was 49.6 and the experimental class, which was 47. The data shows that the initial abilities of the two classes were not much different. Then after being given treatment, the average value of the posttest control class became 54.8 while the experimental class became 67.6. It was proven that the posttest scores of both classes showed an increase in learning outcomes, but a large increase occurred in the experimental class that applied the polya heuristic strategy. The normality test was carried out to find out whether the data distribution from the research results was normal or not. In this study the normality test used was the Shapiro-Wilk test based on the probability or significance value(Mohd Razali & Bee Wah, 2011).

Testing the normality of the data with the Shapiro-Wilk test was carried out with the help of the SPSS version 22 program with a significance level used was 0.05. If the output value in the sig. from the test results in SPSS is greater than the significance level (Þ> 0.05) then the data is normally distributed and vice versa if the output value is in the sig. From the test results in SPSS it is smaller than the significance level (Þ≤0.05), so the data is not normally distributed. The results of the normality test in this study can be seen in Table 3.

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Table 3. Tests of Normality

	Respondent class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Experimental pretest value	Experiment	.265	25	.000	.811	25	.000
	Control	.238	25	.001	.813	25	.000

a. Lilliefors Significance Correction

From these data it is known that the data is not normally distributed (Þ = <0.001), therefore, the next step is to do Next, the Wilcoxon test analysis was carried out to test the hypothesis in Table 4.

Table 4. Test Statistics[a]

Class	Pretest
	posttest value - pretest value
Z	-2.949[b]
Asymp. Sig. (2-tailed)	.003

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

Data analysis on the results of the pretest and posttest essay questions is used to test the research hypothesis stated in H_0 and H_1, namely:

H_0 = There is no significant effect of the heuristic strategy on improving students' mathematical literacy skills

H_1 = There is a significant influence on the application of heuristic strategies to increase students' mathematical literacy abilities.

Based on the hypothesis test, the polya heuristic model's effect on increasing students' mathematical literacy was analyzed. Price t count compared to t table, which is contained in the t distribution table. the required testing criteria required hypothesis is accepted Ho if ($-t_{table} < t_{hitung} < t_{count}$) at a significant level of 0.05 for other prices Ho is rejected. The following is a table 4 of hypothesis test calculations using Wilcoxon.

From the results of the analysis it is known that there is an increase in the interest of respondents (the average pretest score with high interest is 19.52 points and the average posttest score which has a low score of 17.39 points), to look for the influence of the polya heuristic strategy applied in solving problems to increase literacy skills students' mathematics and statistically significant (p = <0.001) A set of general method instructions in the Polya strategy can improve student learning outcomes, especially in advanced elementary school students (Rosydiana, 2017). At the stage of cognitive development, namely the stage of concrete action where elementary school students are at the stage of starting to show new abilities to give reasons to calculate what must be done(Marinda, 2020). Based on this, it is assumed that elementary school students are able to apply the steps of the Polya strategy.

The results of this research aim to prove whether the polya heuristic strategy is more effective than conventional learning strategies, to determine the effect of polya heuristic strategies on increasing students' mathematical literacy, and to describe the effect of polya heuristic strategies on students' mathematical problem solving abilities. Based on the results of the study it was proven that the polya heuristic strategy had an influence on increasing students' mathematical literacy skills in solving mathematical problem solving. increasing students'

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mathematical literacy skills in solving mathematical problem solving. This is evident from the increase in the posttest scores of the students' problem solving abilities in the experimental class which were higher than the scores in the control class students. The average acquisition value is 54.8 for the control class and 67.6 for the experimental class.

These results are in line with research (Habibie et al., 2022) The purpose of this study was to determine the differences in students' critical thinking abilities after receiving learning with the Polya heuristic strategy compared to the critical thinking abilities of students who received mathematics learning with conventional learning, and how students' attitudes toward learning mathematics with the Polya heuristic strategy. This study used an experimental method on the entire population of class VII students at SMPN 1 Muara Bungo, while two classes were randomly selected as samples. The instruments used are tests of critical thinking skills and attitude scales. The results of this study can be concluded that: (1) students' critical thinking skills who receive mathematics learning with the Polya Heuristic Strategy are better than students who receive conventional learning models; (2) students have a positive attitude towards learning mathematics by using the Polya Heuristic Strategy. The author suggests that the Polya Heuristic Strategy can be used as an alternative for teachers to carry out the teaching and learning process in the classroom and to carry out similar research to reveal comprehension abilities in other mathematics subject matter.

In addition, the success of the polya heuristic strategy on students' mathematical literacy skills in solving mathematical problem solving is also strengthened by(Rosyada & Retnawati, 2021) who implemented the polya heuristic strategy using a randomized control group pretest-posttest design using cluster random sampling techniques. The experimental group is the group of students who are taught with the polya heuristic strategy, and the control group is the group of students who are taught with the conventional approach. The population is 280 students of class X SMA. Samples n = 74 for the experimental class, and n = 72 for the control class were taken through cluster random sampling. Based on data analysis through analysis of covariant, it was found that learning with the polya heuristic strategy was better than conventional approaches to students' abilities in solving mathematical problems.

Another thing that supports the success of the heuristic strategy of the Polya model in solving mathematical problems is also in line with research (Sariati et al., 2012). which states that this research aims to improve student achievement and motivation through the use of the Polya model heuristic strategy. This research is a classroom action research which consists of two cycles. The research subjects were students of class VIII B semester 2 of SMP Negeri 40 Purworejo, totaling 31 students. Data collection using tests and questionnaires. The research instrument is in the form of tests and questionnaires. Data analysis used the t test and Scheffe method. The results showed that students who scored above KKM 64.00 before the study were 16 students with an average of 64.51 and

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classical learning mastery of 51.62%. In cycle I, there were 23 students who scored above 64.00. The average student achievement increased to 74.41 with a classical learning mastery of 74.19%. In cycle II, there were 26 students who scored above 64.00, so that the average student achievement increased to 78.25 with classical learning mastery of 83.87%.

The t test shows that tcount is more than ttable, so the hypothesis which states that the Polya model heuristic strategy can improve students' mathematics learning achievement is acceptable. In addition, there was an increase in the percentage of students' learning motivation from the first cycle of 72.22% to 79.67% in the second cycle. The heuristic strategy is a learning approach by providing heuristics to the steps of solving mathematics learning problems, the use of heuristic strategies can be used to direct students to conceptual understanding, creativity, mathematical communication, problem solving and reasoning, so that students have high-level thinking skills (HOTS) (Tambunan, 2018).

Another thing that supports the success of students in solving mathematical problem solving above is also related to the approach in developing the level of mathematical ability through the polya heuristic strategy. PISA divides the level of mathematical ability into six levels. PISA is a program carried out by the Organization for Economic Co-operation and Development (OECD) to formulate policies, one of which is an evaluation of skills and knowledge designed for students aged 15 years (Kafifah et al., 2018).

The definition of mathematical literacy according to the OECD in the 2015 PISA Draft Assessment and Analytical Framework is an individual's ability to formulate, use, and interpret mathematics in various contexts (OECD, 2017). The focus of PISA is literacy which emphasizes the skills and competencies of students obtained from school and can be used in everyday life and in various situations(Jumarniati et al., 2016), the indicators used refer to the level of PISA mathematical literacy ability can be seen in Table 5.

Table 5. Math ability level

Levels	Description
1	Using knowledge to solve routine problems, and can solve problems in a general context.
2	Interpret problems and solve with formulas.
3	Carry out procedures well in solving problems and be able to choose problem solving strategies.
4	Work effectively with models and be able to select and integrate different representations, then relate them to the real world.
5	Work with models for complex situations and can solve complex problems.
6	Using reasoning in solving mathematical problems, can make generalizations, formulate and communicate the findings.

The Table 5 describes the level of mathematical ability developed by PISA. Mathematical literacy questions at levels 1 and 2 are included in the group of questions with a lower scale that measures reproductive competence.

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The questions are arranged based on contexts that are well known to students with simple mathematical operations. Mathematical literacy questions at levels 3 and 4 belong to a group of questions with a medium scale that measure connection competence. Medium-scale questions require student interpretation because the situations given are unknown or have never been experienced by students.

Meanwhile, level 5 and 6 mathematical literacy questions are included in the group of questions with a high scale that measures reflection competence. These questions demand high-level interpretation in contexts that are completely unexpected by students (Putri & Putri, 2022).

Based on the approach in developing the ability level of mathematical literacy, students are faced with contextual problems or real problems that will help them construct their knowledge. At this stage students will use their literacy abilities to formulate real problems into mathematical problems, then solve them and interpret them in real contexts. What is meant by real is that the problem describes the general context and the actual problem. The problems used in learning are also not just any problems. The problems used should meet the following four characteristics: real, complex, interesting and strong (Asmara, A. S., Waluya, 2017).

The main components in problem-solving mathematical literacy include 4 components, namely exploring, connecting and reasoning logically and using various mathematical methods. This component is used to facilitate solving everyday problems which at the same time can develop students' mathematical abilities.

CONCLUSION AND SUGGESTION

Based on the results of research data analysis carried out and after being treated with the experimental class using the polya heuristic strategy and the control class using conventional methods. Apart from that, there are differences in the average literacy abilities of students before and after implementation. It can be concluded that the implementation of the polya heuristic strategy on mathematical literacy skills in arithmetic operations has had a positive impact, namely making students understand the concepts in a material quickly, there is a change in student behavior where they are more motivated to achieve. Students look more confident, diligent in participating in learning activities, and optimistic in solving problems.

The research results will contribute to the world of education, especially in the development of literacy-based learning innovations to improve mathematical literacy skills.

Suggestions for research that has been carried out and future research are in implementing more conceptual learning so that students are more enthusiastic about learning mathematics.

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