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Improving Students' Mathematical Problem-Solving Ability through the Use of External Representations

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Abstract

This study has the objectives, namely first, to find out whether students' mathematical problem-solving abilities can be improved by using external representations. Second, analyzing student activities in learning mathematics by using external representations. Third, analyzing student responses to learning mathematics by using external representations. This research uses classroom action research (CAR) or classroom action testing (PTK) methods. According to O'Brien in Mulyatiningsih, "action research is carried out when a group of people (students) identify the problem, then the researcher determines an action to overcome it." Classroom Action Research (CAR) seeks to develop and reflect on a learning model with the aim of improving learning processes and outcomes. Based on the results of the research, it can be concluded that: learning using external representations can improve mathematical problem solving abilities; it can be seen that there is an increase in the number of students who score above the KKM in cycle II, with the percentage of students who are declared complete (reaching the KKM) at 71.4%, or as many as 20 students are higher than in cycle I, with a percentage of 53.57%, or as many as 15 students who are declared complete. This means that most students have achieved learning mastery resulting from learning through the use of external representations.
Keywords: representation, classroom, learning, student.

Abstrak

Penelitian ini memiliki tujuan yaitu pertama, untuk mengetahui apakah kemampuan pemecahan masalah matematis siswa dapat ditingkatkan dengan menggunakan representasi eksternal. Kedua, menganalisis aktivitas siswa dalam pembelajaran matematika dengan menggunakan representasi eksternal. Ketiga, menganalisis respon siswa terhadap pembelajaran matematika dengan menggunakan representasi eksternal. Penelitian ini menggunakan metode penelitian tindakan kelas (PTK) atau pengujian tindakan kelas (PTK). Menurut O'Brien dalam Mulyatiningsih, "penelitian tindakan dilakukan ketika sekelompok orang (siswa) mengidentifikasi masalah, kemudian peneliti menentukan suatu tindakan untuk mengatasinya." Penelitian Tindakan Kelas (PTK) berupaya mengembangkan dan merefleksi suatu model pembelajaran dengan tujuan untuk meningkatkan proses dan hasil pembelajaran. Berdasarkan hasil penelitian dapat disimpulkan bahwa: pembelajaran dengan menggunakan representasi eksternal dapat meningkatkan kemampuan pemecahan masalah matematis; terlihat adanya peningkatan jumlah siswa yang mendapat nilai di atas KKM pada siklus II, dengan persentase siswa yang dinyatakan tuntas (mencapai KKM) sebesar 71,4%, atau sebanyak 20 siswa lebih tinggi dari pada siklus I dengan persentase 53,57% atau sebanyak 15 siswa yang dinyatakan tuntas. Ini berarti bahwa sebagian besar siswa telah mencapai ketuntasan belajar yang dihasilkan dari pembelajaran melalui penggunaan representasi eksternal.
Kata Kunci: representasi, ruang kelas pembelajaran, siswa.

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INTRODUCTION

Education is the main factor in the progress of a nation. Good education produces the best graduates, who are expected to become implementers of national development. Along with the times, the problem of education has received a lot of attention from the community. To support the development of human resources (HR) who are competitive in responding to the challenges of an ever-changing era, quality education is required. This is in accordance with the educational objectives stated in Law No. 20 of 2003, Article 3, concerning the National Education System, namely: "National education functions to develop capabilities and form dignified character and national civilization in order to educate the nation's life. It aims to develop the potential of students to become human beings who believe and fear God Almighty, have noble character, are knowledgeable, capable, independent creatives, and become democratic and responsible citizens."

One way to develop the competitiveness of human resources (HR) is through education conducted in educational institutions that organize learning processes in schools. One part of education in schools that can make an important contribution to students' development of human resource competitiveness is learning mathematics. Aspects of knowledge that are developed in learning mathematics include the ability to solve problems. As stated in the attachment to Permendiknas No. 22 of 2006 Concerning Content Standards (Ministry of National Education, 2006), mathematics subjects aim for students to have the following abilities: (1) understanding mathematical concepts; (2) reasoning; (3) solving problems; and (4) mathematical communication.

From the explanation above, it is clear that to increase the competitiveness of human resources (HR), education is carried out by institutions that provide education. One part of education that develops students' competitiveness is learning mathematics because learning mathematics can improve students' problem-solving abilities, so students must do it. This can be seen from the results of research conducted by the Trend in International Mathematics and Science Study (TIMSS) on class VIII students in 2011, which were still low. In 2011, Indonesia was ranked 38th in the field of mathematics, with a score of 386 out of 42 countries. The questions raised in TIMSS are not only at a low cognitive level such as remembering, understanding, and applying but at a high level, namely reasoning, which includes the ability to analyze, generalize, synthesize, assess, and solve non-routine problems.

The subject matter contained in the TIMSS questions is divided into several more specific topics, such as: Recall, recognize, compute, retrieve, measure, and classify or sort are all examples of knowledge. Applying includes selecting, representing, modeling, implementing, and solving routine problems. Analyzing, generalizing or specifying, integrating or synthesizing, justifying, and solving non-routine problems are all examples of reasoning.

The conclusion from research conducted by TIMSS is not much different from research conducted by PISA in 2015, which found that Indonesia is ranked 64th in the field of mathematics with a score of 397 out of 70 countries. Specifically at level 2 (score 420–482), students can interpret

and recognize situations in contexts that require no more than direct inference, extract relevant information from a single source, and make use of a single representational mode; at level 3 (score 482–545), students can execute clearly described procedures, including those that require sequential decisions; and at level 4 (score 545–607), students can work effectively with explicit models on complex, concrete situations that may involve constraints or call for making assumptions. According to data from the 2015 PISA results, it shows that around 54% of students are proficient at level 3 or more (proficient at levels 3,4,5, or 6), around 29% of students are at level 4.5 or 6, around 10.7% of students are at level 5 or 6, and only 2.3% of students are at level 6. So students' mathematical abilities are still at a low level. Because the PISA assessment process involves skills in communication, mathematization, representation, reasoning, and argumentation, determining strategies to solve problems, and using symbolic language, formal language, and technical language as mathematical tools.

The use of symbols in solving mathematical problems includes the embodiment of representation. Representation is an important competency for students to have in learning mathematics. This can be seen in the expected goals for learning mathematics set by the National Council of Teachers of Mathematics (NCTM). NCTM (2000) defines five standards of mathematical ability that must be possessed by students, namely problem-solving abilities, communication skills, connection skills, reasoning abilities, and representation abilities.

This statement is reinforced by Brenner's statement, which says that a successful problem-solving process depends on problem representation skills such as constructing and using mathematical representations in words, graphs, tables, equations, solving, and symbol manipulation. This means that creating words, graphs, tables, equations, and manipulating symbols is part of the external representation. External representations are embodiments of what students, teachers, and mathematicians do internally.

In line with the characteristics of mathematics as a science that is systematic or has links between its materials, it shows that there is a necessity to master the prerequisite material, which forms the basis of new mathematical material. So that each student feels ownership of the external representation in order to improve students' problem-solving skills toward higher-order thinking.

Based on observations made by researchers when carrying out observations on integrated teaching profession practice activities, in fact, the teacher is still teacher-centered in learning and, when explaining a material to students, immediately gives the mathematical formula, without first associating it with the students' previous knowledge or with their daily lives. As a result, when the teacher asks questions, students can only work on questions that are routine in nature, while students cannot work on questions that are different or non-routine in nature, because students are not involved in learning and concept discovery, so students' reasoning does not work. Besides that, in working on the questions, students only solve them in the form of symbolic representations, so that the other representations are not honed. Likewise, with the results of the research conducted by Rista Ayu, it

can be seen that students' external representation is lacking; students who have medium and low levels of representation ability are still not able to solve problems related to their external representation abilities properly. Students also still have a lot of confusion when rewriting the questions given in the form of pictures or tables.

This study has the objectives, namely first, to find out whether students' mathematical problem-solving abilities can be improved by using external representations. Second, analyzing student activities in learning mathematics by using external representations. Third, analyzing student responses to learning mathematics by using external representations.

METHOD

This research was conducted at MTs Darussalam Perigi Baru, which is located at H. Rasam Street, RT.003/02 Perigi Baru Village, Pondok Aren District, and South Tangerang City. This research was conducted in the class VII even semester of the 2021–2022 academic year. The research was carried out in the even semester, from March 27 to May 3, 2022. The subjects of this research were class VII students at MTs Darussalam Perigi Baru, totaling 28 people in the 2022 school year. One person who acted as an observer in this study was a class VII mathematics teacher who was an observer of the course of the research. During the implementation of the action, the observer helps the researcher observe student responses during the learning process, writes down things that are not in accordance with the plan, and together with the researcher reflects on the results of the action's implementation.

This research uses classroom action research (CAR) or classroom action testing (PTK) methods. According to O'Brien in Mulyatiningsih, "action research is carried out when a group of people (students) identify the problem, then the researcher determines an action to overcome it." Classroom Action Research (CAR) seeks to develop and reflect on a learning model with the aim of improving learning processes and outcomes. In full, classroom action research aims to: (1) improve the quality of content, processes, and learning outcomes in the classroom; (2) improve teachers' professional abilities and attitudes; and (3) cultivate an academic culture so as to create a proactive attitude in improving the quality of learning. Classroom action research is carried out in several cycles until the desired results are achieved. The cycle is a round of successive activities that returns to its original step. One class action research cycle includes four stages: (1) planning, (2) action, (3) observation, and (4) reflection. Cycle I is carried out if the indicator of success has not been reached, then cycle II is carried out, but if cycle I has achieved the indicator of success, cycle II is still carried out to ensure the success of the treatment. However, if in cycle II the indicators of success have not been achieved, cycle III is carried out using the results of reflection in cycle II as a reference in preparing cycle III plans. When cycle I and cycle II indicators of success have been achieved, the research is stopped.

HASIL DAN DISKUSI

Students' Mathematical Problem-Solving Ability

At the end of each cycle, a test is given that measures students' mathematical problem solving abilities. The test given contains six questions that contain indicators of problem solving, namely understanding the problem, making a model plan, completing the model plan, and interpreting the results or solutions. The test results of the students' problem-solving abilities were as follows: there was an increase in the average score between cycles I and II on each indicator of mathematical problem solving. Of all the existing indicators, only the indicator for making a model plan experienced a decrease in the average value, which was 0.18 points. The findings of this indicator's analysis, namely, that the interpretation process was not carried out extensively in cycle I, but the questions given in the final test in cycle I were in the moderate category with a difficulty level of 0.32 points, made it easier for students to answer these questions. Low student interpretation in cycle I demands positive changes in cycle II. In cycle II, more interpretation processes were carried out, especially interpreting an illustration into image form. With so many interpretation activities in cycle II, students are getting used to interpreting mathematical problems from illustrations to pictures or vice versa. In the final test of cycle II, the interpretation questions given were a little more difficult, causing students to not be optimal in answering these questions, which had an impact on the decrease in students' interpretation of the indicator test results.

The ability to complete the model plan, which was still low in cycle I at 45.36 points, made researchers make learning changes in cycle II. One of the efforts made is to increase students' time in carrying out the discussion process to understand problems and orders. In the process of discussion, students are faced with problems that are able to develop their problem-solving abilities. Then, in group learning, students are accustomed to expressing their opinions to one another in problem solving rather than waiting for the teacher to explain first. This resulted in an increase in the indicator of completing the student model plan by 39.28 points.

The ability of students to interpret low results or solutions in cycle I, which was equal to 28.04 points, made researchers carry out additional directions and provide lots of examples in cycle II in order to get maximum results. One way to do this is to provide problems based on everyday life. One of them lies in the solution stage. At the last meeting, students were asked to understand the problems in word problems related to real life and then solve these problems and interpret the final results obtained from the calculations. In cycle II, the ability to interpret the results or solutions reached a score of 73.75. This shows a significant increase between cycle I and cycle II, namely achieving a score of 45.71.

Student Activity

In comparison to the other aspects, the visual activities aspect has seen the least improvement. An increase of 6.67% in cycle II was due to the fact that in cycle II, the students' focus on paying

attention to the explanations from the teacher and their friends had increased. Increasing student activity in the aspect of visual activities also plays a role in improving other aspects, especially aspects of oral activities.

The aspect of oral activities that focused on measuring student activity in expressing opinions, asking questions, and answering questions posed by friends in discussions experienced a very significant increase of 11.67%. The increase in this aspect was due to the fact that the discussion process that took place in cycle II was more active than in cycle I. Students who were still passive during the implementation of cycle I began to be able to express opinions in the discussion process in cycle II. There are rules in discussion cycle II that require students to be able to understand the results of their group discussions so that the material presented during the discussion is more optimal than in cycle I.

The writing activities aspect experienced an increase of 38.33%. This aspect emphasizes the focus of observation on student activity in drawing conclusions about the final results of problem solving. In cycle II, students must be able to draw conclusions with their group mates so that they are always ready when asked later by the researcher. These requirements and demands cause students to be more active in carrying out activities in this aspect compared to the implementation of cycle I.

The next aspect is drawing activities, which have increased by 13.33% in cycle II. There are several factors that cause this increase, one of which is the activeness of students in making or describing flat shapes according to their types on buildings in real life. In cycle II, students are able to describe flat shapes according to orders. Motor activities, which measure student activity in carrying out direct motoric processes in learning, have increased by 5%. This increase occurred because in cycle II students were given more space to be directly involved in the process of searching for data and measuring objects in everyday life.

The mental activity aspect increased by 26.67%. In this aspect, students' activities in remembering and using previous knowledge to solve problems become the focus of observation. The mental activity aspect increased by 8.33%. In this aspect, students' activities in remembering and using previous knowledge to solve problems become the focus of observation. The increase occurred because there were more discussions compared to cycle I, which made students repeat information that had been obtained repeatedly and made it easier for students to remember previous learning material.

The emotional activities aspect experienced an increase of 18.33%. Students are more enthusiastic and enjoy the learning process in cycle II because the material is more related to everyday life and students are more active in the learning process. This is the main factor in increasing the average percentage in this aspect.

Student Response

Students' daily journals were used to collect data on their reactions to learning about external

representation. Based on the data that has been obtained, there has been an increase in students' positive responses from learning cycles I to II.

All researchers hope that carrying out classroom action research will lead to an increase in positive student responses in each cycle and a decrease in negative and neutral responses from students. The increase in students' positive responses was 17.85%, and respectively, there was a decrease of 8.33% and 9.53% in students' neutral and negative responses to the external representation learning that was carried out during cycles I and II.

There are many factors that influence student responses, but the most prominent are related to the ongoing learning process and the material being studied. Students will feel happy if the learning process is fun and conducive so that they can absorb the material being taught. But the material being studied is also another factor. If students are involved in making learning fun, but the material being studied is difficult, students become less enthusiastic and lose focus, making the learning difficult to understand.

Discussion

The research findings revealed that students' mathematical problem-solving abilities (KPMM) increased in cycle I by 53.21 and in cycle II by 71.39. The achievement of the KPMM score in cycle II was 71.39, indicating that as many as 20 students, or 71.4%, had achieved the KKM. This means that the KPMM achievements have met the success criteria, namely that 70% of students get a score above the KKM. The increase in students' KPMM was supported by improvements in the learning process summarized in the reflection of cycle I. Several improvements were made, including improvements in writing down known and asked information in understanding problems, improvements in planning models and discussion processes in completing model plans, and improvements to the interpretation of the results or solutions made by students in solving problems.

The findings of this study differ slightly from the findings of Santia's (2013) research, which took respondents from high school students and looked at the aspect of learning style, and reported that representation of high school students in solving problems is the optimum value for students with a fild independent cognitive style by understanding the information and what is asked by making drawings, making a solution plan by making mathematical equations, manipulating numbers, and manipulating words. While the subject solves problems from the field using an independent cognitive style, he does so by understanding information and what is asked by writing mathematical equations using formal symbols, making plans for solving by making mathematical equations, manipulating these equations, and using trial and error, without re-checking the final results that are obtained. Santia's findings also report that the methods used by independent and field-dependent fields are almost the same as learning external representations.

External representation learning with each of its interrelated stages, namely translation, integration, and solution, where the three stages focus more on the discussion process in forming

understanding of new concepts so that students understand problem solving, make plans, complete plans, and finally interpret results or solutions, so that students with average problem solving ability levels can benefit from the stages of representation. external. The findings in this study are in line with previous findings by Roza Leikin et al. (2013). The results of the study indicate that external representations have a very important effect on the process of solving mathematical problems for students who have ordinary abilities. Student activity during learning by using external representation is one of the focuses of this research. The research findings revealed that student activity increased by 61.43% in the first cycle and 80.00% in the second cycle. Achievements The percentage of student activity in cycle II was 80.00%, which indicated that the percentage of learning activities during learning using external representations met the expectations of researchers, namely 75%.

Learning with external representation is no longer teacher-centered but instead provides opportunities for students to construct and develop their understanding independently, making them more active. This is in line with research findings by Jarnawi (2011), who reported that some students were able to develop forms of representation by using mathematical logic processes. Students begin to formulate representations using known premises, arrange tables, make conjectures, and then arrange formal representations.

Based on students' daily journals, the positive response of students during learning by using external representations from cycle I to cycle II increased by 17.85%, with a breakdown of the percentages for each cycle, namely 64.29% and 82.14%. The average percentage of students' positive responses was 82.14% in cycle II, which is an indicator of the success of this study, namely that the average percentage of students' positive responses during learning reached at least 80%. This shows that learning with external representations can increase students' positive responses. Students who give a positive response to external representational learning because learning by way of discussion is different from learning usually give more freedom for students to process existing information, and LKS-assisted learning can make it easier for students to understand the material provided. Students' negative and neutral responses are more influenced by the level of difficulty of the material being studied.

External representational learning in this study provides more learning that is able to assist students in understanding problems and solving problems from their mathematical ideas, which are then communicated through external representations. This finding is in line with the opinion of Goldin and Shteingold, who stated that mathematical ideas are communicated through external representations whose forms include spoken language, images, concrete, and written symbols. Number systems, algebraic expressions, mathematical formulas, geometric shapes, and graphs are models of representational forms.

CONCLUSION

Based on the results of the research, it can be concluded that: learning using external representations can improve mathematical problem solving abilities; it can be seen that there is an increase in the number of students who score above the KKM in cycle II, with the percentage of students who are declared complete (reaching the KKM) at 71.4%, or as many as 20 students are higher than in cycle I, with a percentage of 53.57%, or as many as 15 students who are declared complete (reaching the KKM). This means that most students have achieved learning mastery resulting from learning through the use of external representations. The use of external representations in mathematics learning can increase student learning activities. This increase can be seen in aspects of student learning activities, namely in the visual aspects of activities where students are able to pay attention to the explanations of fellow group members without having to wait for the researcher to explain, aspects of emotional activities, aspects of oral activities where students are able to actively give opinions in discussions, Aspects of writing activities students are able to write down the final conclusions from solving problems with their groups.

In aspects of drawing activities, students are able to describe shapes according to orders and describe shapes according to their types on buildings in real life. Students are directly involved in the process of searching for data and measuring objects in everyday life; the mental aspects of students' activities are able to remember and use previous knowledge to solve the problems given; and the emotional aspects of students' activities are more enthusiastic in the learning process with material related to everyday life. In general, students' positive responses indicated an increase in learning through the use of external representations.

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