

PBL-based STEM: Its effect on the cognitive learning outcome of junior high school students

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ABSTRACT

The PBL (Problem-based Learning) model based on the STEM approach is very suitable for raising students in the midst of today's increasingly rapid development of the digital era which is based on a problem that encourages students to learn and work cooperatively in groups to find solutions, think critically and analytically, and able to use appropriate learning resources. This study aims to determine the effect of the PBL learning model based on the STEM (Science, Technology, Engineering, and Mathematics) approach to students' cognitive learning outcomes at MTs Muhammadiyah 1 Malang. Sampling with purposive sampling technique. This type of research is a Quasy experiment with a Non-Randomized Control Group Pretest-Posttest Design research design. The population in this study were students of class VII MTs Muhammadiyah 1 Malang which consisted of 2 classes. The data analysis technique for cognitive learning outcomes of students uses the data requirements test with the SPSS version 22.0 for Windows program. The collection of research data used an instrument in the form of multiple-choice tests for students' cognitive learning outcomes. Based on the results of hypothesis testing using the ANCOVA test, a sig value of $0.005 < 0.05$ is obtained because the sig value is smaller than 0.05, so it can be said that H_0 is accepted which shows that the STEM-based PBL model has a significant influence on students' cognitive learning outcomes. Based on the data obtained, it can be concluded that there is a significant influence in the use of the PBL model based on the STEM approach to students' cognitive learning outcomes at MTs Muhammadiyah 1 Malang.

Keywords: Approaches, learning outcomes, models, problem-based learning, STEM

INTRODUCTION

Students' critical thinking skills can be built by providing learning experiences and designing appropriate learning processes (Jariyah & Husamah, 2024; Rahardjanto et al., 2019; Ramdiah et al., 2019; Susetyarini et al., 2022). Teachers design learning by providing problems that involve students' thinking skills and involve an analysis process based on actual problems. Planned learning can create a pleasant learning atmosphere and students actively develop their potential to gain knowledge, understanding and ways of behaving in accordance with their needs. (Rahman et al., 2022). Based on survey results related to the secondary education system in the world in 2018 issued by PISA (Program for International Student Assessment) in 2019, it shows that Indonesia occupies a low position,

namely ranking 74th out of 79 other countries, so it can be seen that Indonesia is in the 6th lowest position compared to other countries (Nurhuda, 2022). Meanwhile, the 2022 PISA results show that the literacy, mathematics/numeracy and science abilities of Indonesian students are still relatively low despite an increase in ranking. The literacy ability ranking of Indonesian students in 2022 is at 71. The mathematics ability ranking is at 70. Meanwhile, the science ability ranking is at 67. In 2022 there will be 81 countries included in the PISA rankings (OECD, 2023).

Education in Indonesia still has many problems which include low student responsibility and the quality of existing education. Student achievement decreases, they do not do their assignments, they do not take class picketing to a high level, and they lack enthusiasm

in learning. These problems can be minimized with several efforts, one of which is organizing subjects with appropriate models, approaches and learning systems in the teaching and learning process (Kadi & Awwaliyah, 2017).

Based on the results of observations carried out in class VII MTs Muhammadiyah 1 Malang in the Biology subject, several things were found related to the learning process, namely that some students sometimes chatted with their friends and did not pay attention to the material presented by the teacher, were less enthusiastic, did not do their assignments and activities. low learning. One of the factors causing this problem is the implementation of learning that is not appropriate to the material being taught. Inappropriate learning has a negative impact on understanding the material and low student learning outcomes. Biology study results for 22 Class VII students at MTs Muhammadiyah 1 Malang had scores below the Minimum Completion Criteria of (70) or were incomplete, totaling 15 students and 7 students who scored above the Minimum Completion Criteria or students who completed.

One possible effort that can be made to improve students' cognitive learning outcomes is by implementing a PBL (Problem-based Learning) model based on STEM (Science, Technology, Engineering, and Mathematics) (Phandini et al., 2023) in the learning process carried out using blended learning. The PBL model is a way of building and teaching by using unstructured problems as a stimulus and focus on learning (Anggraini et al., 2020; Khoiriyah & Husamah, 2018). The learning process begins with problem discovery as a focus or stimulus for solving problems or reasoning, as well as information or knowledge to understand the mechanism of a problem. This model provides conditions for improving critical thinking and analysis skills as well as solving complex problems in real life, so that it will create a culture of thinking in students in the learning process (Robiyanto, 2021).

The STEM approach is an interdisciplinary

learning between science, technology, engineering and mathematics that focuses on solving everyday problems, both in real life (Sitorus, 2022). STEM creates an active learning system, because it is supported by these four aspects at the same time in solving problems (Sumaya et al., 2021). The application of STEM-based learning will further motivate students to excel and get the best grades and can motivate students to be more active in discussions (Alkautsar et al., 2023).

Learning with the Blended Learning system is a process of combining learning with face-to-face meetings in class and integrated activities that are facilitated with computers, the internet and various other learning media (Husamah, 2014, 2015b, 2015a). Blended learning will give students the opportunity to be active and make the learning process enjoyable (Puspitarini, 2022). The application of Blended learning facilitates teachers to still be able to interact with students and carry out their functions well, but at the same time be able to utilize technology, so that in carrying out face-to-face learning, teachers also utilize technology-based learning, so that students can have their needs met, whether interacting directly with the teacher, or via a gadget or computer to explore the material being studied (Widiara, 2018).

Based on the first previous research, conducted by Kurniawati and Hidayah, (2021) concluded that there is an influence of the Blended Learning-based problem-based learning model on students' scientific literacy abilities. The results of research on scientific literacy skills in the experimental control class were that research in the experimental class was better than research in the control class. The limitations of this research are students in class VII even semester 2020/2021 (experimental class VII G and as a control class class VII H), using the PBL model, Blended Learning learning system, the aspect studied is students' literacy abilities, testing students' literacy abilities using scientific literacy test consisting of 10 questions, quantitative research type, using the Quasy

Experiment method with the research design The Posttest Only Control Group Design, and the sampling technique using Cluster Random Sampling.

The second further research was conducted by [Habibah et al., \(2022\)](#), concluded that there is an influence of the application of the Blended Learning-based Problem-based Learning model on students' critical thinking abilities, with the results of hypothesis testing of students' critical thinking abilities with a significance level of $0.000 < 0.05$, and the average post-test score for the experimental class was 88, 51 and the control class is 78.00. The limitations of this research are class XI IPA students at SMAN 2 Mataram (class XI IPA 2 as the experimental class and Critical thinking for Class purposive sampling.

Therefore, it is necessary to conduct research using a blended learning system regarding student learning outcomes in schools by linking PBL-based STEM. The aim of this research is to determine the effect of the Problem-based Learning model on students' cognitive learning outcomes at MTs Muhammadiyah 1 Malang.

METHOD

This research is a quasi-experimental research or Quasy Experiment using a nonrandomized control group pretest-posttest design. The population of this study were all class VII students at MTs Muhammadiyah 1 Malang. The sample for this research is students VII A as the experimental class and VII B as the control class.

The experimental class was given treatment in the form of a PBL model based on a STEM approach with a blended learning system, while the control class used conventional learning with a blended learning system. In the experimental class, treatment was given using the PBL model of learning without using a STEM approach. There are five steps or stages in implementing the PBL model in learning. The first stage is orienting students to the problem. The second stage is organizing students to study. The third stage is guiding individual and group investigations. After finding a solution to the problem through the

information collected, the fourth stage is developing and presenting the results of the work. The fifth stage is analyzing and evaluating the problem-solving process. The learning process is carried out 2 times per week for 3 weeks by each class.

The technique for collecting data on cognitive learning outcomes uses a multiple-choice test with 20 questions. The data analysis technique for this research uses the SPSS version 22.0 for Windows program which includes a normality test with One Sample Kolmogorov Smirnov and a homogeneity test with the Levene Test of Equality, N-Gain test, Average Difference Test, hypothesis testing using the ANCOVA Test.

RESULTS AND DISCUSSION

Based on the results of statistical tests, the two sample classes are normally distributed and come from a homogeneous population. Next, an N-Gain test was carried out to determine the increase in cognitive learning outcomes or comprehension abilities before and after the test with an average N-Gain value for the experimental class of 0.7 while the average N-Gain for the control class was 0.3. The next step was to test the difference between the averages of the two samples, showing that the average score for the experimental class with the Problem-based Learning learning model was 70.35, while the average score for the control class learning outcomes was 61.50.

The final step is to test the hypothesis using the ANCOVA test. This is done to find out whether the research hypothesis is accepted or rejected. The ANCOVA test results (Table 1) on students' cognitive learning outcomes show that the Sig. (2-tailed) value in the "Equal variances assumed" section is $0.005 < 0.05$, so it can be concluded that H_0 is rejected and H_a is accepted, which means there is a significant influence of the model Problem-based Learning on students' cognitive learning outcomes. Thus, it can be concluded that there is a significant (real) difference between the average student learning outcomes in the experimental class and the control class.

Table 1. ANCOVA test results student cognitive learning results.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2721.892 ^a	2	1360.946	50.895	.000
Intercept	2060.159	1	2060.159	77.044	.000
pretetes	1841.632	1	1841.632	68.871	.000
Kelas	229.292	1	229.292	8.575	.005
Error	1123.086	42	26.740		
Total	199997.00	45			
	0				
Corrected Total	3844.978	44			

Based on the results of the comparison of learning outcome scores, it can be seen that students who use the STEM approach-based PBL model (experimental class) on student cognitive learning outcomes have higher scores when compared to students in the control class. Increasing students' cognitive learning outcomes cannot be separated from the factors that influence these students. One of the factors that can influence student learning outcomes is the student's internal factors. Internal factors are factors that originate from within an individual that influence cognitive learning outcomes, namely psychological factors which include attention, interest, talent, motivation and students' initial abilities (Suarmawan et al., 2019).

Students who have high initial abilities may find it easier to understand the material, compared to students who have low initial abilities because the possibility of difficulty in understanding the subject matter provided by the teacher is very large (Zulkarnain, 2019). Students' initial abilities are a determining factor in the success of learning and describe students' readiness to receive lessons that will be delivered by the teacher, including the knowledge, skills and abilities that students have mastered in learning new tasks. Students' initial abilities before the relevant learning process begins have a big influence on the cognitive learning outcomes that will be achieved (Astuti, 2015).

Another factor that influences students' cognitive learning outcomes is external factors.

External factors are factors from outside the individual that influence learning outcomes such as the family which includes the way parents educate, relationships between family members, the family's economic situation, and school environmental factors such as learning models and methods applied by teachers to students (Suarmawan et al., 2019). The role of the teacher is very important in the learning process, where the teacher becomes a role model in the learning process by teaching high-level thinking processes (Husamah et al., 2019; Husamah & Pantiwati, 2014). A learning process that is still teacher-centered can cause students to not be active and students' mindsets will not be able to develop due to experiencing boredom or boredom in following the learning process. As a result, many students have difficulty understanding the material presented by the teacher (Syuhada et al., 2020).

Other external factors that influence improving student learning outcomes cannot be separated from the PBL model learning syntax based on the STEM approach. The syntax of Problem-based Learning is different from the syntax of other learning models. Where the syntax of the Problem-based Learning model based on the STEM approach from the beginning of learning has trained students in higher level thinking. The implementation of the learning process is observed based on activities carried out during the student learning process including orienting students to problems, organizing students around problems, guiding individual and group investigations, developing and presenting work results, and analyzing and evaluating the problem-solving process.

Students are given assignments in the form of problems that are still unsolved. The student's task is to solve the problem by finding the right solution. Based on the various kinds of problems that have been given, students formulate the problem and look for a solution. The problem solving process is carried out by discussing in groups so that students can share knowledge and exchange ideas with other students. When solving problems, students can search from

various sources of information, whether from books, worksheets, or the internet. After obtaining appropriate sources of information as a solution, the solution to the problem can be solved and proven in the poster making assignment, then continued with a class presentation together. This presentation activity will lead to a process of discussion and exchange of information again within the class group. Because other groups provide responses to each other in the form of questions or suggestions. Based on this, students can gain new experiences and insights and sometimes find new related problems to be solved. The application of this PBL model makes students explore their own knowledge because the teacher's role is only as a facilitator, not as sharing knowledge.

The PBL model based on the STEM approach improves student learning outcomes in the process of working on a problem from a given assignment by the teacher. Students are given more responsibility or emphasis on learning so they can develop their own knowledge, understand the problems given by the teacher, and can carry out problem investigations. both individuals and groups, solving problems by developing the work results obtained, as well as analyzing and evaluating the problem solutions that have been chosen. The improvement in student learning outcomes that occurs with the implementation of the Problem-based Learning model based on the STEM approach is also supported by problem formulation activities which require students to provide arguments for the question and provide deductive or inductive conclusions on a given problem (Hotimah, 2020). High learning outcomes will be achieved by students if during the learning process in the classroom, teachers build interaction and communication patterns that place more emphasis on the process of actively forming knowledge by students. The more frequently the teacher provides feedback to students during the learning process, the more students' abilities will develop in formulating problems, solving problems, arguing, and answering questions from

the teacher (Rahmadani, 2019). This is proven by the increase in student learning outcomes after being given PBL model treatment.

The STEM approach is an approach to education that combines Science, Technology, Engineering, Mathematics integrated with an educational process that focuses on solving real problems in everyday life, such as environmental pollution or climate change. Learning with a STEM approach is very suitable for raising children amidst today's increasingly rapid digital era developments. This approach makes it easier for students to solve problems by getting information from all sources with sophisticated technology and developing STEM abilities in the learning process (Davidi et al., 2021; Nurwidodo et al., 2022). The PBL model based on the STEM approach is used because of the harmonious combination of problems that arise in the real world and learning that focuses on solving problems that we often encounter in everyday life (Naura et al., 2022). The PBL model based on the STEM approach can improve student learning outcomes because during the learning process students gain learning experience, not just memorizing learning material. However, students are also able to integrate science, technology, engineering and informatics which are used to solve problems in everyday life. Applying the STEM approach to classroom learning, information is formed through collaborative risk taking and creativity, meaning that students can use science, technology, engineering and mathematics skills in the learning process to think and solve problems (Sumaya et al., 2021).

Based on the findings of previous research which also analyzed the influence of the STEM integrated PBL model to improve the activities and learning outcomes of students in class XII IPA 5 SMAN 7 Padang (Ningsih, 2020) states that the implementation of the STEM integrated Problem-based Learning model can be observed based on activities carried out during the learning process including orienting students to problems, organizing students around problems, guiding

individual and group investigations, developing and presenting work results, and analyzing and evaluating the problem solving process. Before starting the learning process based on PBL syntax, students are divided into small groups. Even though individual abilities are required for each student, in the learning process in the PBL model students learn in groups to understand the problems they face. Then students study individually to obtain additional information related to problem solving. The teacher's role in PBL is as a facilitator in the learning process (Lestari et al., 2017).

The initial stage of the learning process with PBL syntax, namely student orientation to the problem, the teacher explains the learning objectives, materials and equipment that will be used for demonstrations and raising problems, and motivates students to be involved in problem solving. Next, at the stage of organizing students on a problem, the teacher helps students to identify and organize learning tasks related to the problem that will be studied in groups (observing the pictures or problems available on the student worksheet). Then at the stage of guiding individual and group investigations, the teacher encourages students to collect appropriate information, carry out experiments, to obtain explanations and solve problems. Then the stage of developing and presenting the work, the teacher helps students plan and prepare the work, helps students share assignments with their friends. At this stage, students discuss with their small groups about the factors that cause the problem and present them in a group discussion. Meanwhile, in the final stage, the teacher and students reflect or evaluate the investigation process that has been carried out and students discuss their perceptions of the problem in class.

STEM-based PBL can improve student learning outcomes, this can happen because (1) students are challenged to solve real problems, (2) students become more active in learning, (3) students are given the opportunity to solve problems related to the concept of the subject matter that must be achieved during this

learning, (4) students acquire various skills (STEM) that they need in the competitive environment of the 21st century (5) students can understand the concept of knowledge and can apply it as a solution to solving problems (Melati, 2019).

Increasing students' high-level thinking abilities has an effect on increasing students' intellectual abilities, so that they can increase their ability to understand the concepts that have been studied or learned during the learning process. High level thinking needs to be developed from an early age, because high level thinking can enable students to solve problems in everyday life. Students will be able to understand the concepts studied if the students have a sense of responsibility as students to learn and complete the tasks given by the teacher. The character of responsibility encourages students to prepare time to study lesson material, submit assignments on time, make reports (notes) after completing activities, accept the risks of actions that have been taken, and admit mistakes that have been made (Sari, 2021).

The character value of responsibility in students must be formed optimally. If this is not formed optimally, it is feared that it will result in negative behavior such as ignoring school assignments, not focusing on learning and ultimately passing off responsibility to others. Irresponsible student behavior will ultimately have a significant impact on students' personal development and achievement of learning outcomes (Suryadi, 2018).

CONCLUSION

Based on the results of the hypothesis test, it can be concluded that there is a significant influence with the application of the STEM approach-based PBL model on students' cognitive learning outcomes at MTs Muhammadiyah 1 Malang with a sig value of $0.005 < 0.05$ because the sig value is smaller than 0.05, so it can be said that H_0 is accepted, so it can be concluded that the use of the STEM-based PBL model has a significant influence on students' cognitive learning outcomes.

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