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The Effect of the Problem Based Learning Model Supported with the Theory of Multiple Intelligences on Mathematics Achievement

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ABSTRACT
This was experimental research that aimed at revealing the effect of the problem-based-learning model supported with the theory of multiple intelligences on students' mathematics learning achievement and retention. The research respondents were 200 students at a secondary school who were divided into two groups, namely the group taught using the problem-based-learning model supported with the theory of multiple intelligences (PBLMI) and that taught using the traditional one (direct instruction). The instruments used were the mathematics learning achievement test, inventory test for multiple intelligences, and personal information form. The research results indicate that the PBLMI model has a statistically significant effect on students' mathematics learning achievement compared to the traditional one. It can be concluded that the PBLMI is more effective than the traditional one. Further, students who take longer mathematics lessons show better academic achievements than those who take shorter ones. There is no, subsequently, a significant difference between the retention of students taught with the PBLMI model and those taught with the traditional one. However, it does not mean that the PBLMI model is not effective on retention since they are provided with the retention test one month after the post-test. During this time, students are absent from school due to the Covid-19 pandemic. Thus, the changes in students' social life for about one month may have caused a loss of attention to the mathematics lessons. For this reason, it may be inappropriate to conclude that the PBLMI model is not effective on students' retention in mathematics lessons.

Keywords: *Theory of multiple intelligences, Problem-based-learning, Mathematics learning achievement.*

1. INTRODUCTION

Like many other countries, mathematics has become one of the most important subjects in the curriculum. One of the objectives of learning mathematics at schools is to help students acquire the skills needed to solve daily problems and develop students' skills, independent thinking, and self-control [1]. Mathematics subjects play a crucial role in developing reasoning skills, critical thinking, and problem-solving. Therefore, teachers must teach mathematics to helps students to develop their intellectual skills. Even though mathematics has been allocated in an intensive weekly time, the success of teaching mathematics in Indonesia cannot be considered satisfactory. Several things are associated with the cause of students' failure in learning mathematics, including mathematics topics that consisted of abstract concepts [2], which became a challenge for students to change them into concrete topics. In general, this abstract concept causes students to tend to have difficulty and even experience failure in learning mathematics.

Based on the explanation explained before, it is necessary to pay attention to how mathematics is taught to make the mathematics learning process more meaningful, and students can actively participate in the learning process both mentally and physically.

Therefore, one of the central roles for teachers is to choose and manage learning situations that will provide a learning experience to students and what and how mathematics should be taught to become an exciting subject for students. The fact that learning models are still teacher-centered is one of the reasons for student failure in learning mathematics. Thus, changes or modifications need to be made with new learning. As in the constructivist learning paradigm, the teacher is a facilitator and mediator who oversees the student learning process. Students must be actively involved in education, cooperate with others, and use their own learning styles to achieve success in learning [3]. Students need maturity and individual study skills to develop their performance and acquire skills that will help them develop their performance

The learning conditions created by the teacher will determine the success of learning, where the teacher can accommodate various individual characteristics of students. Each student has their own characteristics. Teachers must consider individual differences and set up an appropriate learning environment [4]. In this context, the theory of multiple intelligences (MI), proposed by Howard Gardner, suggests student-centered teaching and an approach that considers students' differences [5]. The learning environment, which accommodates students' multiple intelligences, will allow students to discover themselves and their potential. Furthermore, this theory also provides an opportunity for educators to organize programs that appreciate the individual differences among students [6]. Nowadays, many learning models have been developed, have been organized, and applied based on the theory of multiple intelligences (MI). One of them is a problem-based learning model suitable for student development activities such as concept explanations that begin with contextual problems and a cooperative and collaborative learning atmosphere.

According to the 2013 curriculum, the stages of the problem-based learning model are student orientation to problems, organizing students, guiding individual and group investigations, developing, and presenting work, and analysing and evaluating problem-solving processes. Many techniques will be found if these steps are examined, such as brainstorming, views or suggestions, problem-solving, discussion, individual learning, etc. These activities are in accordance with the theory of multiple intelligences (MI). The problem-based learning model developed today has involved multiple intelligences (MI), including interpersonal intelligence, intrapersonal intelligence, and verbal-linguistic intelligence. The activities in this model have applied multiple intelligences principles to the learning process, although only a few are involved. Therefore, this study is focused on a problem-based learning model by maximizing the involvement of students' multiple intelligences.

The problem-based learning model is student-centered, and its activities allow for stimulating several types of multiple intelligences. The integration of problem-based learning supported by the theory of multiple intelligences into mathematics learning can accommodate the different intelligence among students. Teaching materials can be made meaningful to all students with this integration. For example, a student whose mathematical or logical intelligence is lacking may become the leader of a group whose activities require kinesthetics skills. Therefore, students with different intelligence are grouped into heterogeneous teams that aim to complement each other, and they can try themselves to be more successful. The implication of this integration of classroom activities will strengthen several types of multiple intelligences that can lead students to work together. Many studies in Indonesia and abroad have conducted studies on the effectiveness of the learning process supported by multiple intelligences (MI) on mathematics materials [7].

Many studies have shown that the multiple intelligences (MI)-supported learning process cannot improve students' mathematics learning achievement. However, it has succeeded in turning the classroom into a pleasant environment by showing positive effects on students' class participation and motivation. Some experimental studies have been conducted on the effect of several learning models on learning achievement. The results found that the developed learning model has not had a significant effect on student achievement. For this reason, innovation must modify learning. Howard Gardner states that education that can accommodate dominant multiple intelligences for students can change learning to be more fun. The students' love of what they are learning will have implications for their learning achievement. On this basis, the effectiveness of the learning model supported by multiple intelligences (MI) is interesting to study. This study was conducted to analyze the effect of problem-based learning supported by multiple intelligences (MI) on students' academic achievement and its effect on student retention in learning mathematics. The objectives of this study:

1. To determine the effectiveness of problem-based learning supported by multiple intelligences (PBLMI) on students' academic achievement and retention in mathematics subjects
2. To determine the significant differences in students' academic achievement and retention who are taught using the PBLMI model in a short

time and students who are taught using the PBLMI model in a relatively long time.

To determine the effectiveness of PBLMI for eighth-grade students of junior high school on retention in mathematics subjects

2. METHOD

This study was conducted at one school in Bone Regency. The participants were mostly students from the middle socioeconomic class in the 2019/2020 academic year. Indonesia has a nationally applicable curriculum. Therefore, this study was conducted based on the relevant curriculum. The topics taught in the study were adjusted to the curriculum material that is applied. Students in one of the experimental groups were taught mathematics using PBLMI for ten weeks. The other three groups (one experimental and two control groups) were randomly selected. One group of the experimental classes was taught mathematics using the PBLMI for a long time. The other experimental group was taught using the exact method, but the duration was shorter. Furthermore, in one of the controls and experimental groups, the researcher acted as a teacher who taught the learning material to the students. Meanwhile, the researcher still developed the learning material in the other control group, but the classroom teacher instructed the students using a direct teaching model. Mathematics achievement test, Personal Information Form (PIF), and The Teele Inventory for Multiple Intelligences (TIMI), which previously developed, were used to obtain data.

2.1. Mathematics Achievement Test

In this study, the researcher developed a mathematics learning achievement test to measure academic achievement. The items in this test were determined based on the topic indicators taught during the research. 4 experts and practitioners have validated items from the developed test. The test was conducted in two stages to avoid the saturation of students in working on the questions. Each student was asked to complete the questions given for 45-60 minutes.

2.2. Personal Information Form (PIF)

Before the experimental process begins, the researcher distributed the personal information form to students intended to obtain data on the background of students' socio-demographic. The data were also used to organize problem-based learning teams in experimental groups.

2.3. The Teele Inventory for Multiple Intelligences (TIMI)

Teele Inventory for Multiple Intelligences (TIMI) was not developed by the researcher but used an instrument developed by [8]. This instrument is designed to test the dominant intelligence of students in all classes. TIMI is an instrument that contains images with choices consisting of 56 images that represent the characteristics of each of the nine intelligence and give students 28 opportunities to make their choices. Students were asked to choose one of the two options that they feel most appropriate. There is no right or wrong answer in this instrument. Students will choose, and each selected image represents the score for the intelligence associated with that image, and the answer sheet is coded. The more frequently selected intelligence indicating the student's dominant intelligence. The answer sheets allow students and teachers to determine the most dominant intelligence indicated by the highest score. This test is also used to identify the type of intelligence at the beginning of the distribution of the instrument in determining the most dominant intelligence of the participants. These data were used to conduct problem-based learning in the experimental group

2.4. Treatment

In this study, PBLMI was used in the experimental group. At the same time, the traditional teaching model was taught in the control group. The groups in the experimental class were divided based on the results of TIMI and PIF and academic achievement variables. Various activities which focus on eight different intelligence were conducted for four weeks. The objective was to increase students' awareness regarding their intelligence. Furthermore, the researcher also prepared a teamwork handbook given to the team to learn and understand together. Therefore, all teams know how to organize students in the learning process and how they will be assessed. After that, in the learning process, all teams were instructed to follow the steps in the plan based on the objectives and PBLMI for ten weeks. Studies by several previous researchers, such as ([5], [7]) were used as references for preparing class procedures based on PBLMI.

Class activities within the framework of the theory of multiple intelligences (MI) reveal individual differences. Problem-based learning activities based on the theory of multiple intelligences (MI) can be seen in Figure 1 below

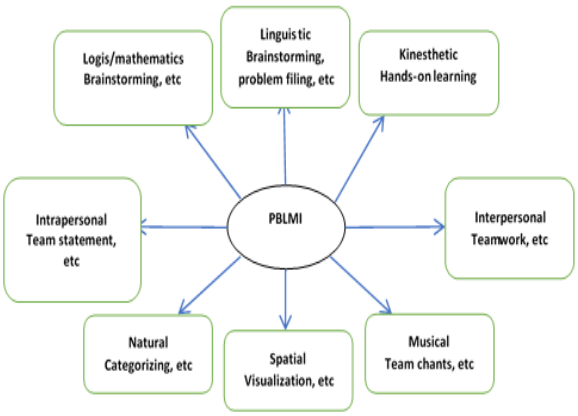

Figure 1 Problem-based learning activities

The learning process begins with organizing activities that students will perform. Further, the teacher will start the learning process by explaining the contextual problems related to the topic. Students are also asked to express their ideas after the teacher gives them stimulus through the problems raised. In contrast to the traditional way, groups of students who use a problem-based learning model supported by multiple intelligences (MI) had actively participated in activities in heterogeneous groups. The researcher (and teachers) act as guides in presenting subjects based on the PBLMI model. After the topic ends, students will carry out an individual test. The team scores are based on individual scores.

For the control class, a traditional teaching model was applied using the direct teaching model. The teacher explained to the students how the teaching and learning process would be conducted. They were informed about the class rules. After that, the teacher presented the topic, and several problems related to the topic were solved. Several problems were solved based on the learning objectives. In the problem-solving stage, the teacher explained to the students in detail, and students are allowed to ask questions. After that, the teacher will give questions or problems, and students are asked to solve them. When students have solved the problem, the teacher gives them feedback and makes some corrections. Many problems are solved during the learning process. The teacher also gives homework assignments to the students. In the next lesson, their homework is controlled. No group work was conducted in the control group.

2.5. Data analysis

The data analysis used for the data obtained from the achievement test, is ANOVA, analysis of covariance (ANCOVA), and pairwise comparisons. ANOVA was used to determine whether there was a significant difference in the mean pre-test scores of all groups. The ANOVA results showed that there was no significant difference between the mean pre-test scores of each group. Furthermore, it was found that there was a strong linear relationship between the pre-test (covariate) and post-test scores. Therefore, covariance analysis was carried out to observe the difference between the group's mean post-test scores. A pairwise comparison test is used to determine the direction of differentiation. Similarly, analysis of covariance was performed to determine differences between retention scores between groups.

3. RESULT

One of the objectives of the analysis is to determine the differences in the mean of pre-test scores of students' mathematics learning achievement in the experimental group and the control group. Analysis of variance from four groups was performed to determine the results. The ANOVA analysis results showed no significant differences in the mean of pre-test scores of the four groups [p = 1,26 > 0,05]. Furthermore, a summary of the descriptive statistical analysis of the pre-test, post-test, and retention scores of the control and experimental groups is shown in Table 1.

Table 1. The descriptive statistics (pre-test, post-test, and retention score) of the student in control and experiment

Groups	N	PRE-TEST		POST-TEST		RETENTION	
		M	SD	M	SD	M	SD
PBLMI A	40	14,39	6,21	33,57	7,22	27,63	8,27
PBLMI B	40	12,03	4,73	36,07	5,81	26,09	9,54
Control_researcher	40	12,76	5,54	17,74	6,09	20,73	6,54
Control_teacher	40	11,52	6,89	19,89	8,32	17,66	7,97

Description: PBLMI A is the application of a long-duration learning model
PBLMI B is the application of a short duration learning model

The following data analysis uses ANCOVA with pre-test as a covariate for post-test scores and post-test as covariates for retention scores. The analysis results found significant differences between the students' learning achievements using PBLMI models and using traditional learning models. The results indicated by the probability value [0,000 < α = 0,05]. The analysis results also showed significant differences in learning achievement between students who are taught using PBLMI models in a long time and students who are taught using PBLMI models in a brief time [probability value of 0,000 < α = 0,05]. In addition, the retention scores of each group found that there were no significant differences, which was indicated by a greater probability value than α = 0,05 [0,080 > α = 0,05].

4. DISCUSSION

The findings in this study were found through the results of data analysis using the PBLMI model, which is effective in improving academic achievement in mathematics subjects. In other words, the PBLMI model is used more effectively compared to traditional learning models, which is indicated by the significant difference in academic achievement between the experimental groups and the control groups. Furthermore, it was also found that the application of the PBLMI model in a long time had a better impact on student academic achievement compared to the application of the PBLMI model in an abbreviated time. The results showed that using the PBLMI model in the long term will be much more effective in improving students' academic achievement. However, the results obtained in this study did not show significant differences in the retention value between students who taught using the PBLMI model and using the traditional teaching model.

The study results show the importance of making students as subjects in learning, building student motivation, practicing communication and collaborative skills in the learning process, and so on as in the activities that have been performed in the PBLMI model. Moreover, the activities in the PBLMI model are also more accommodating to stimulate the differences in intelligence possessed by each student. It turns out that these activities have an impact on more effective learning. Effective mathematics teaching requires teaching methods to improve students' skills and readiness to learn. Therefore, it is necessary to arrange a more oriented class towards student-centered learning activities and create a pleasant learning environment to support learning activities. PBLMI is one of the learning models that can be used as an alternative to accommodate these activities. In the PBLMI model, the activities conducted in learning the topic are varied, such as working in groups, understanding problems through reading, writing problems in a mathematical model, calculating, solving problems in collaborative forms, sing in rhythm, and various art forms. One of the noticeable characteristics in the PBLMI learning model is learning activities set with heterogeneous group activities. Therefore, students support each other. Each student is encouraged to be active and takes responsibility in a team, guided to respect differences in views, and trained to communicate. According to Kartikasari [9] stated that these activities could significantly affect student academic achievement. Further, La Ndia [10] said that if teachers can prepare student classrooms that can facilitate different intelligence or consider other intelligence preferences, students will be more active and happier in the learning process, impacting student achievement.

Several studies that have been conducted include Gülşah & Halime [11], which states that learning that allows students to have different ideas, varied learning activities, and learning that is adapted to students' real world are highly effective in improving students' academic achievement; Gökhan Baş [12] shows that learning combined with the theory of multiple intelligences can improve academic achievement. The findings are in line with the results showing that PBLMI is more effective than traditional teaching models. Students were more confident in using their knowledge in problem-solving, and the study groups tend to be more successful. Moreover, the research finding of Kartikasari [9] also supports the findings in this study. Kartikasari [9] also conducted experimental research on the differences between the multiple intelligence's theory-based learning model and the traditional learning model. The study found that multiple intelligences theory-based activities encourage students to be actively involved and more responsible in learning. Therefore, students' academic achievement has increased significantly.

Another finding from this study is that PBLMI is more effective for students who participate in the long-term PBLMI model than the group of students who participate in the short-term PBLMI model. These results indicate that the effectiveness of a learning model can increase as the implementation process is extended. Even though studies that focus on using a multiple intelligences theory-based learning model in the long term are still lacking, the research findings of Isk & Kamuran Tarin [1] are in accordance with the research results conducted. Isk & Kamuran Tarin [1] revealed that using cooperative learning supported by the theory of multiple intelligences can be beneficial for both students and teachers. It also improves student achievement when its application is extended. Thus, it can be said that it is necessary to consider individual differences regardless of the model or learning method used in teaching mathematics.

A good learning process is when the learning environment allows students to learn differently [13]. In the theory of multiple intelligences, everyone has more dominant intelligence than other intelligence. Therefore, this study reinforces the idea that to obtain good performance, the teacher must facilitate the learning process in many ways. This perspective is in line with Gardner 14, which also revealed that one of the things that must be prepared in the classroom is to formulate different activities to accommodate the various dominant intelligence possessed by students. Mathematics teachers must be able to prepare and mix their materials, teaching strategies, and methods in

accordance with learning objectives to achieve this goal.

Many works of the literature show that numerous studies have been conducted on the involvement of theory of multiple intelligences in the learning process in different subjects (science, mathematics, language, social studies, music, etc.). The findings of the studies ([7]; [8]; [9]) are consistent with the results of studies conducted using the PBLMI model, where the PBLMI model has considered individual differences and provided a situation for student development. The learning process that involves the theory of multiple intelligences provides opportunities for students to recognize their potential in learning and can help in personal and social development, such as self-confidence and communication skills. In practice, PBLMI activities have been designed so that students can support each other, socialize with each other, and help each other. Thus, students could get to know each other. Moreover, using the PBLMI model makes students feel happy and can also improve their attention to factors related to education such as topics, schools, and teachers, classrooms [6]. If the learning process conducted is in line with these objectives and is carried out in the long term, then as in the findings of this study, it can be concluded that the process is more effective in improving students' academic achievement.

The last finding of this study is that the retention scores of students who taught using the PBLMI model are not significantly different from the retention scores of students who taught using the traditional teaching model. However, the results obtained were not strong enough to prove that the PBLMI model was ineffective on retention scores for mathematics subjects because the retention test was conducted one month later due to the COVID-19 pandemic outbreak when the students must study from home. Therefore, it is possible for changes in social life that can reduce students' attention to their subjects, and the experimental process is negatively affected. Based on these assumptions, this study cannot conclude that PBLMI is ineffective in student retention scores for mathematics subjects. This finding is supported by research conducted by Isk & Kamuran Tarin [1], which states that the indication that cooperative learning supported by multiple intelligences is not effective on student retention scores is the occurrence of changes in student social life. The retention test is not conducted directly and must wait for a few weeks later. According to scientists, one's knowledge retention is strongly influenced by the stimulation given to the brain, which means that the more often the human brain is stimulated, the longer the knowledge retention. For this reason, long-term studies using the PBLMI model need to be conducted to obtain satisfactory learning achievements and good retention scores in mathematics.

AUTHORS' CONTRIBUTIONS

In this study, it was only carried out by a single researcher whose roles were starting from studying the study conception and design, collecting data, analyzing data, interpreting the results of data analysis, and reporting research results in the form of articles.

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