The Effectiveness of the Development of Problem Based Learning Model Based on Bakiak Game Technology in Mathematics Learning in Elementary Schools

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Abstract. The aim of this study was to determine the effectiveness of the development of the bakiak game-based PBL model in mathematics learning in elementary schools. The study used the Research and Development (R n D) research method which was simplified into seven stages. Active, creative, innovative, and contextual problem-based mathematics learning must be considered. PBL as an alternative to the learning model needed today. Learning mathematics is learning that many students do not like. Learning must be transformed using attractive media. One of the technologies that can be used is bakiak games. This game is fun and can be used to discover the concept of speed as a comparison of distance and time. The results showed the development of the PBL model based on bakiak technology in mathematics learning was proven to be effective and could increase students' activity and mathematics learning outcomes.

1. Introduction
The mathematics learning process that is needed now is innovative, creative, and meaningful learning. One of the learning processes that prioritizes innovation, creativity and meaning is the Problem Based Learning (PBL) model. PBL is the most significant learning innovation that develops contextual problems [1], [2], [3], [4]. PBL is indeed widely practiced, but on a certain side some researchers question the effectiveness and efficiency of PBL. PBL causes unstructured thinking process, thinking chaos occurs, even students can experience stress. at the problem-solving stage PBL places a higher burden on brain memory [5], [6], [7]. The age of development of elementary school (SD) students is still tied to concrete objects that can be easily captured by the five senses. Learning difficulties experienced by students are in understanding formal mathematical concepts. mentioned that students who are at the concrete operational stage prefer to manipulate concrete objects. In the research Zullyaet.al [8] also use problem based learning model, and the result is problem based learning has been proven to improve students' math problem solving competence, like the research Ahmad Wakit and R. Hadapiningraja [9] students' problem-solving competence increased after following the learning with the problem-based learning model and the students' process skills in following the learning in the 2013 curriculum increased significantly. They really like playing activities that manipulate concrete objects [10], [11], [12]. Indonesia has high technology and culture. One of the technologies they have is traditional games. There are many traditional games that can be applied in learning mathematics. One of the known game technologies is bakiak. This game can be used as a medium for learning mathematics, especially the concept of speed as a comparison of distance and
time for fifth grade elementary school students. The development of the clog-based PBL model is designed as follows:

1. **Syntax**
   - **Orientation to the problem**: The teacher explains the learning objectives, explains the logistics needed, proposes phenomena or stories to raise problems in everyday life.
   - **Organizing students to learn**: The teacher helps students to define and organize learning tasks related to the problem. The teacher directs students to organize and design their own activities.
   - **Guiding individual and group investigations through clog games**: The teacher encourages students to collect appropriate information, conduct experiments and investigations to get explanations and problem solving by facilitating students to play clog games using game rules.
   - **Helping students analyze data**: Helps students to analyze data from the results of clogging games to determine the mathematical concepts of speed, distance, and time.
   - **Finding the concept of mathematical formulas**: Directs students to find the formula for speed as a ratio of distance and time.
   - **Developing and presenting the work**: The teacher facilitates students to make works, compiles valid arguments, and creates their findings.
   - **Analyzing and evaluating processes**: The teacher facilitates students to reflect or evaluate their investigations and the processes they use.

**Figure 1.** The design of the development of a PBL model based on clog games

Based on the results of the study, the initial design of the model components is obtained, namely (1) syntax, (2) social systems, (3) reaction principles, and (4) support systems, and (5) the instructional impact.

1.1 **Syntax**

The learning model syntax describes the structure of teaching, elements or stages of learning [13]. Based on the results of this research and development, there are seven stages of learning which are the result of the development of the previous five stages. Stage I (student orientation to the problem) the teacher explains the learning objectives, explains the logistics needed, proposes phenomena or demonstrations or stories to raise problems in everyday life; Phase II (organizing students to learn) The teacher helps students to define and organize learning tasks related to the problem. The teacher directs students to organize and design their own activities. Stage III (guiding individual and group investigations through clog games) The teacher encourages students to collect appropriate information, conduct experiments and investigations to get explanations and problem solving by facilitating students to play clog games using game rules; Stage IV (helping students analyze data) helps students to analyze data from the results of clogging games to determine the mathematical concepts of speed, distance, and time; Stage V (helping students find the concept) directs students to find the formula for speed as a ratio of distance and time. Stage VI (developing and presenting the work) The teacher facilitates students to make works, compiles valid arguments, and creates their findings; Stage VII (analyzing and evaluating processes) The teacher facilitates students to reflect or evaluate their investigations and the processes they use.
In the third stage, guiding individual and group investigations is carried out by integrating clogging games using 2 rules. The first rule of the game is to find the relationship between speed and time (distance is equal) and the second rule is to find the relationship between speed and distance (time is equal). From this game students will find out the factors that affect speed; the relationship between speed, distance and time; which in the end discovered the velocity formula is the ratio between distance and time.

The integration stage helps students analyze data and the stage helps students find concepts based on the researcher's experience and analysis of the needs of developing models. At the guiding stage of the investigation, many students experience failures in the thinking process which ultimately are unable to solve the problem, it is necessary to emphasize the stages to help students analyze game data and help to find mathematical concepts or speed formulas as a comparison of distance and time.

1.2 Social System
The principles contained in the interaction pattern of the social system of society are working together to solve problems between students, teacher-students, and groups, freedom of expression, student cooperation between groups during learning. Therefore, it is intended to produce mutually agreed solutions to problems. In this learning model students need to communicate with each other. The teacher acts as a facilitator and the learning center lies in the activeness of students.

Bakiak game is one of the traditional games. This game uses a long wood that has been smoothed and given some slippers on it like sandals. This game tests agility, leadership, cooperation, creativity, insight and honesty which are very suitable for learning in elementary schools. This forecasting can be used as an educational interaction to find the velocity formula as a comparison of distance and time in mathematics lessons in grade V Elementary School.

The habits of students who passively accept knowledge, and the habits of teachers who dominate students in learning that are very irrelevant to the demands of future learning, can be changed through the patterns of social system interaction in society. According to Bruce, when the teacher begins to be considered the initiator of the teaching stages and determines the series of learning activities, he must be responsible for controlling the rest by cooperative means [13]. This is in accordance with the results of this research and development, in the implementation of learning the teacher and students are able to work together to solve a problem. Students are able to collaborate with fellow students or with teachers. The teacher as a facilitator and learning center lies in student activities. In developing this model the teacher helps, guides students in processing data to find the mathematical formula for distance, time and speed.

1.3 Reaction Principles
The implementation of the learning model is based on constructivism theory and the social system values of society that emphasize student-centered learning, so that the teacher functions as a facilitator and mediator in learning. Principles of Management or teacher reactions to students vary widely. The things that the teacher does, such as providing student orientation in understanding problems in daily life, are in accordance with the subject matter, providing adequate learning resources such as worksheets, teaching materials and learning media. Inviting to play activities, practicum, or demonstrations. The teacher directs and guides students in groups or individually to find mathematical concepts from the activities that have been done. In addition, the teacher also motivates students to be able to communicate their work both orally and in writing in front of the class. At the end of the lesson the teacher must also help students to reflect and evaluate their investigations and findings.

1.4 Support System
This learning model is supported by a support system so that learning can be carried out practically and effectively. The support system for this model includes a syllabus, lesson plans (RPP), teaching materials, and student worksheets (LKS).
2. Research Method

This research uses a research and development design which refers to the theory of Borg and Gall. According to Borg and Gall in Sugiyono[14] states that research and development (R & D), is a research method used to develop or validate products used in and learning.

The data subjects in this development research were class V SDN Pakis 01 with 36 students as the experimental class and class V SD Islam SalafiyahMargomulyo with 19 students as the control class. The data that will be taken in this research is the trial data of the Problem Based Learning (PBL) model based on bakiaik game technology in mathematics lessons on the subject of speed in elementary schools. Hypothesis testing involves two population groups, so hypothesis testing uses the t-test. Researchers tested the effectiveness of the model using differences in the results of the pretest-posttest experimental group and control group. Preparation of pretest or posttest questions takes into account the level of thinking and is adjusted to the learning objectives. Pretest or posttest.

2.1 System Analysis

The small-scale product trial design used in model development is the One Group Pre-Test Post-Test Design, can show in table 1.

| Q1 | X | Q2 |
|----|---|----|

Table 1. Design One-Group Pre-Test Post-Test Design Source: Sugiyono[14]

Information:
Q1: pre-test value (before being given treatment)
Q2: post-test value (after being given treatment)

The large-scale product test design used in the development of the Problem Based Learning model based on bakiaik in mathematics learning in elementary schools uses the Pretest-Posttest Control Group Design, interpreted in Table 2.

| A   | O1 | X | O2 |
|-----|----|---|----|
| A   | O3 | X | O4 |

Table 2. Research Trial Design, Sugiyono[14]

Information:
O1: P Pretest of experimental class
O2: Post-test results for the experimental class
O3: Control class pretest
O4: Results of the control class post-test

2.2 System Design

Learning development can be carried out by teachers independently. The development of the learning phase is based on the syntax of the PBL model based on bakiaik games. The lesson plan is used by the teacher as a guide in implementing classroom learning. The learning stages in the development of the PBL model based on bakiaik games, can show in table 3.

| Learning Stages | Teacher Activity | Student Activity |
|-----------------|------------------|------------------|
| preliminary     | Pray             | Pray             |
|                 | Sing the national anthem | Sing The National |
|                 | Delivery of goals |                  |
|                 | Motivation       |                  |
Core
Student Orientation to Problems
Ask questions to attract attention and motivate.
The teacher provides a lure to remind the concept of learning that has been done by the teacher.
Answer the teacher question

Organizing students to learn
Organizes students and directs students to make research designs to investigate problems
Make research design to investigate problem

guide Individual and group investigations
Teacher invites students to do game activities outside the classroom
Students play a game using game rule 1 and game rule 2
Students discuss in groups to analyze the results of the game

Help analysis of activity results find the concept
The teacher helps students in analyzing game result data
The teacher gives directions to help students find concepts through discussion and questioning
Students discover concepts

Developing the Work
Submission of upcoming activities
Prayers together
Students work on questions
Students pay attention and

Evaluation
In The teacher asks students to make a report on the results of the activity
Students make conclusions
Students note what must be prepared for further learning

Closing activities
The teacher asks students to do the questions
The teacher discusses questions vites to be grateful for the smooth learning activities
Doing prayer together
Grateful for the smooth running of learning activities

3. Results andDiscussion

3.1 Results
The trial was limited to testing the effectiveness of the bakiak game-based PBL learning model in mathematics learning. The trial was conducted at SDN Pakis 01 Class VA with a total of 16 students. Because it is still in the state of the Covid 19 pandemic, the implementation of learning is carried out by applying health protocols. Learning was carried out in 2 days, namely on Monday, August 24, 2020, and Monday, August 31, 2020 which took place at SDN Pakis 01. The first learning had not used the PBL model based on bakiak and the second was in accordance with the model development book.
The results of student learning activities in mathematics learning about the concepts of speed, distance, and time at SD Negeri Pakis 1, Tayu District were obtained through observations made in learning. The aspects observed included 6 indicators of student activity in learning, namely:

- Students' enthusiastic attitude towards learning
- The activeness of students in playing bakiak
- Students' skills to analyze
- Students' skills to find mathematical concepts
- Students' skills in developing and presenting work
- Students are able to carry out the tasks given by the teacher.

The results of the recapitulation of student learning activities on limited trials can be seen from the following table.

| Limited Trial | Score | Percentage | Category |
|---------------|-------|------------|----------|
| KBM 1         | 30    | 41%        | Less     |
| KBM 2         | 47    | 66%        | Good     |

Based on the data, it can be seen that there is an increase in the percentage of student activity from the poor category (41%) to good (66%). The recapitulation results can be seen in figure 3.

The value of limited test learning outcomes is obtained from the pre-test and post-test scores. The results of the value are then analyzed and get the results as in the following table.

![Figure 2. Learning Activities](image)

![Figure 3. Graph of Student Activities in Limited Trial](image)
Table 5. Recapitulation of Student Learning Outcomes in Limited Trials

| Limited Trial | Average | Maximum value | Minimum value |
|---------------|---------|---------------|--------------|
| KBM 1         | 63      | 75            | 30           |
| KBM 2         | 82      | 95            | 60           |

An increase in the value of student learning outcomes can be observed in the graphic image of student learning outcomes at the limited trial stage using the development of a PBL model based on bakiak games (Figure 4).

Based on the activity data and student learning outcomes, the author believes that the development of the bakiak game-based PBL model has a good impact on the learning process. The development of the PBL model based on the bakiak game is feasible to be tested on a broader scale.

Wide Scale Trial
The product of the development of the PBL model based on clogging games in mathematics learning in elementary schools was tried out to determine its effectiveness. The trial was carried out at elementary schools in Pati District. In testing and describing the effectiveness of the model, a product trial was conducted by giving treatment to the experimental group and then compared with the learning outcomes in the control class. The experimental class used in this research is class VSD Islam SalafiyahMargomulyo with a total of 36 students as the experimental class. Meanwhile, the control class is SDN Purwokerto 1 with 19 students. Learning in the experimental class is given treatment in accordance with the development of the PBL model based on bakiak games using the learning tools that have been developed. The implementation is carried out by each teacher. While the control class was not given treatment, the researcher only received the results of the activities and grades from the teacher in the control class.

Results of Student Learning Activities
The results of student learning activities in mathematics learning about the concepts of speed, distance, and time in SD Islam SalafiyahMargomulyo, Tayu District were obtained through observations made in learning. The results of the calculation of student activity can be seen from the following table 6.

Table 6. Results of Student Learning Activities in the Development of the Clog-Based PBL Model in Elementary School Mathematics Learning

| No  | Variable          | control class | Score | Experiment class |
|-----|-------------------|---------------|-------|------------------|
| Pre Abilities | Average | 9.2          | 9.28  |
| 1    | Maksimum value    | 13           | 15    |
| 2    | Minimum Value     | 6            | 6     |
| 3    |                   |              |       |
Based on the data in Table 5, it was found that the average initial ability of the experimental class for student activities in mathematics in elementary school on speed, distance, and time was 9.28. After learning with the development of the PBL model based on bakiak, there was an increase in the final ability score with an average of 18.11. Based on the calculation of N gain, an increase in the results over the control class was 0.69 in the moderate category. Regarding the calculation results in the experimental class, there is an increase in N gain with a score of 1.5 in the medium category with an average initial ability score of 9.28 and a final ability score of 18.11. So it can be concluded that the experimental class obtained the highest increase in activity.

Student learning outcomes

To get a picture of improving student learning outcomes using the PBL model based on bakiak games, learning is carried out in accordance with the learning tools that have been made. Learning consists of three stages, namely initial activities, core activities, and closing activities. Before learning begins, students work on pre-test questions first. The pre-test questions are used to determine the level of students' understanding of the material prior to the implementation of learning. Early learning activities are carried out by delivering perceptions, motivation and delivery of learning objectives. In the implementation of core learning activities, it is carried out in accordance with the learning steps that have been arranged according to the development of the model. The final activity of learning, carried out reflection, confirmation and question and answer. After the learning is completed for four meetings then a post test is carried out.

The average difference test was carried out after performing normality and homogeneity. The data analysis used the Independent Sample t-test through SPSS 25. The data were used as values for the initial and final state. The following hypotheses are proposed for the initial state:

H₀: There is no difference in the mean pretest and posttest between the experimental group and the control group

H₁: there is an average difference between the pretest and posttest between the experimental group and the control group

Table 7. Result T-test

| Class        | Nilai sig. | Signifikasi | Conclusion                  |
|--------------|------------|-------------|-----------------------------|
| (Experiment) | Pretest    | 0,041       | 0,05, There is a difference in the average |
| (control)    | Posttes    | 0,000       | 0,05, There is a difference in the average |

The result of the T test (Table 7) shows that the pretest shows the sig value. 0.041 <0.05. Then H₀ is rejected and H₁ is accepted, so it can be concluded that there is an average difference between the pretest scores of the experimental group and the control group. Furthermore, for the results of the posttest value it is also known that 0.000 <0.05 so that H₀ is rejected and H₁ is accepted. In conclusion, there is an average difference between the posttest scores of the experimental group and the control group. Based on the statistical test, it was concluded that the development of the PBL model based on the bakiak game in mathematics learning proved to be effective and could improve students' mathematics learning outcomes.
3.2 Discussion
The results of developing this model have been tested for effectiveness in learning. Based on the tests conducted by the experts, the result shows that the PBL model based on the bakiak game in mathematics learning is categorized as very good by all validators. So that then it can proceed to the field test stage. After going through the expert test, a field test was carried out, carried out in the experimental class learning. In the field test, the results of the pre-test and post-test scores of the fifth grade students of SD Islam SalafiyahMargomulyo were compared with the results of the pretest and posttest control class SDN Purwokerto 1. Then the effectiveness test was carried out using the t test. First the test is carried out prerequisite, the normality test results show that the sample data is normally distributed, and the homogeneity test results show that the sample data is the same or homogeneous.

The result of the T test above shows that the pretest shows the sig value. 0.041 <0.05. Then H0 is rejected and H α is accepted, so it can be concluded that there is an average difference between the pretest scores of the experimental group and the control group. Furthermore, for the results of the posttest value it is also known that 0.000 <0.05 so that H0 is rejected and H α is accepted. In conclusion, there is an average difference between the post-test scores of the experimental group and the control group. Based on these statistical tests, it was concluded that the development of the PBL model based on bakiak games in mathematics learning proved to be effective and could improve students' mathematics learning outcomes. The development of the PBL learning model based on the bakiak game is suitable if it is applied in mathematics learning at this time, because this model is able to develop students' thinking levels in solving problems of learning. This is in accordance with the results of Usman's research, namely the emphasis on learning-oriented activities of students finding mathematical concepts and principles through problem solving which has a direct impact on the application of students in reconstructing concepts [15], [20], [21]. According to Wahab in Murtono, it is explained that an effective learning model must have the following characteristics: having a systematic procedure, measurable learning outcomes, environmental determination which includes supporting factors, measures of success criteria, interaction with the environment [1] [17], [18], [19]. Based on this, the development of a learning model based on bakiak games in learning. Mathematics in primary schools is characterized as a learning model and is worthy of being used as an alternative model for learning mathematics in elementary schools, especially the material of speed, distance and time. The important meaning of the learning model according to Clauhan in Murtono is as a teacher guide, helps develop the curriculum, and helps improve learning [15] Based on this, the development of bakiak-based PBL learning models in mathematics learning in SD can be used as a teacher guide for developing mathematics learning and curriculum in elementary schools regarding speed, distance and time.

4. Conclusion
The activity of the Problem Based Learning model based on the bakiak game concluded that the development of the PBL model based on the bakiak game in mathematics learning proved to be effective and could increase students' mathematics learning activities and outcomes. T test results that show the pretest value of sig. 0.041 <0.05. Then H0 is rejected and H α is accepted, so it can be concluded that there is an average difference between the pretest scores of the experimental group and the control group. Furthermore, for the results of the posttest value it is also known that 0.000 <0.05 so that H0 is rejected and H α is accepted. In conclusion, there is an average difference between the post-test scores of the experimental group and the control group.

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