Problem-based learning with jukung and balogo to improve students’ mental model in south borneo

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Abstract. This study aims to determine the effectiveness of problem-based learning with problems of jukung and balogo to improve students’ mental model of Newton's laws of motion. Jukung is traditional transportation in South Borneo and balogo is traditional game of Suku Banjar. These objects was used as anchor problems for studying Newton's laws. The used research method was quasi-experimental with pretest-posttest control group design. The samples included 46 students of grade X that selected by the cluster random sampling technique. The samples was divided into two groups which consist 22 students of experimental class and 24 students of control class. The data of students’ mental modeling was obtained by six essay items and be analyzed by independent sample t-test. The results of data analysis showed that sig. value of t-test is below than 0.05. In the end of learning the students could describe the phenomenon about force and motion that fit with concepts of Newton’s laws. These results indicate that the problem based learning with problems of jukung and balogo is effective to improve student mental model about Newton’s laws of motion.

1. Introduction

The Newton's laws of motion is the most fundamental laws of classical mechanics. The motion of objects can be described in a simple, clear, and universal way with these laws. It can be used to explain or predict the motion of large or small object [1][2]. It serves as the foundation of classical mechanics, such as impulse, momentum, effort, and energy, so students must understand the Newton’s laws if they want to learn the other concept of mechanics [3]. If a student has understood the causes, effects, or the influence of phenomenon about Newton's law, it can be said that he has right concept or right mental model. Mental models are the internal interpretations about the real world as results from the interaction through the senses [4][5][6]. As part of the problem-solving process, mental models are used to clarify the problems and student can solve it in easy way [7][8][9][10][11][12][13][14].

Some articles reported that there are many students who have misconceptions or uncomplete mental model of Newton's laws [15][16][17][18][19]. The misconception among others: the force must be given to make objects move continuously; there is no force acting on a resting object; the object will automatically stop if the resultant force is removed; the greater the mass of an object, the greater the force that it exerts in collision. Student’s explanation or prediction about a phenomena was not fit with Newton's law that they've learned in junior high school. The initial study was also revealed the students in SMAN 1 Kelua – in Tabalong Regency, South Borneo held those misconceptions. Therefore, the research should be done to improve students’ mental model about Newton’s Laws of Motion.
Several studies about student’s misconceptions in Newton’s laws was done by Anggraini [15], Primayoga [16], Nadhif [17], and Zulvita [19]. But those studies have a shortage because it did not use a perfect modeling cycle. The research of Anggraini, Nadhif and Primayoga did not provide an opportunity for students to test their concept or initial mental model. Teachers only provided learning and hoped the students realize the errors in their mental models. The Zulvita’s research did not even give students the opportunity to evaluate their conception. Students are given an experiment activity but they are not given the opportunity to reflect the concept that have been obtained. Those studies focus on how to deliver information about the correct concept of Newton’s. They did not pay attention about what is the source of students’ misconceptions, what have students understood about Newton’s laws and how are the students understand it. In fact the students’s misconceptions was made from daily experience of the real world that formed a wrong mental model.

Mental models can be generated from new comprehension, prior knowledge, existing ideas, and past experiences. All of them will be used to interpret and explain events in the real world. [5][6]. When a phenomenon has been “understood”, the individual who understands it can know the causes, effects, influences, and how to avoid the phenomenon. Therefore, physics learning should be designed to involve learners in creating and using models because scientific activities are involving the construction, validation, and application of the scientific model [3][20]. By having a mental model, the students will have personal understanding of the learning material [6]. Students can be trained to create and develop models by ask them to explain a phenomenon that has occurred (effect to cause) or predict what will happen (cause to effect) [21][22]. The teacher's role is providing problems and informations that enable student imagine it [11][23]. The more information that can be provided, the easier students easier to build mental models [24]. The learning to form mental model should using problem which is close to students’ daily life. Thus they are able to imagine the problem in their mind [11][23]. The daily life problems also intended for students be able to understand the application of the physics concepts [23]. The mathematical aspects will be considered later, the main priority is to train the basic ability of mental modeling that is analogy, mental simulation, idealization and abstraction [5][6].

The activity to construct mental model that accord with scientific ideas is called mental modelling [4]. Mental modeling process must be accorded with the cycle of modeling, which consist of explore, create, test, evaluate and revise [25]. The modeling cycle will be integrated into Problem-Based Learning as a treatment to the student. Problem-Based Learning is a learning that use a real world problem to motivate student to conduct investigation to answer it [26]. The main component of the Problem-Based Learning is the given problem. The problems must have a connection with the students, based on their experience, and need additional search [27]. The students identify these problems and learn things that are needed to solve them. The use of real-world problems is the teacher’s way to make students learn through investigation, asking, and challenging the thinking in accordance with the constructivism learning theory [28][29][30][31]. In PBL, the students’ understanding is resulted from the interaction with the given problem scenarios and learning environments. The relationship between the problem and the process of investigating the problem will create a cognitive mismatch that stimulate learning. The students’ knowledge can be fostering through a collaborative process of social negotiation and evaluation of one viewpoint. PBL emphasizes learning through learning process of physics products when solving the problem. The lessons will reinforce the concepts of physics in the long-term memory of learners because students are not only informed but also interact directly with the concept being studied [28][32].

The anchor problems for Newton’s laws was related to jukung and balogo (showed in Fig. 1 and Fig. 2). Jukung is a traditional transportation of banjarese tribe and balogo is a traditional game of Suku Banjar. Both of these objects are very well known by the people of South Borneo so it can facilitate the students to create Newton’s laws mental models about those two objects. The students were asked to describe forces on resting jukung that float in the floating market; the cause of jukung still moving though the stroke of the paddle is stopped; and the cause of jukung slowing and stoping when the paddle is stopped. This problem used to investigate the equilibrium of force, the influence of
the inertia to the object’s movement, and the influence of external force against the motion. The problems for Newton's second law is related to the game balogo. Students will be presented the cases of children who play with the altered logo’ masses and modified thrust. The concept to be obtained is the relation between acceleration, force, and mass. The problems that used to Newton's third law is still about the game logo and jukung barenteng (boats pulled by motorboat). Students will be asked to explain why the person who hit the logo is not pushed backwards and why a motorboat can move forward even the motorboat is pulled with as same as magnitude of force by the boats.

2. Methods

2.1. Experimental Design

This research was conducted in the academic year 2017/2018. The samples of this research included 46 students of grade X in SMAN 1 Kelua that selected by cluster random sampling. These samples was divided into two groups such as experimental group and control group. The research design was pretest-posttest control group design as showed by Fig. 3 below. The pretest was given at the beginning of learning to students experimental class and control class. After be given the initial test, the students of experimental class were given the learning with PBL while students in the control class were given the learning used by teachers. The teacher in SMAN 1 Kelua usually teachs students with conventional method, whereas the teacher explain about concepts and equations of physics, and the students just listen to her. After the explanation, the teacher gives the practical example about how to use the equation. At the end of learning, both of experimental and control class were given postest with the same as pretest.

![Figure 1. Jukung as traditional transportation in south borneo (retrieve from aingkumaha.blogspot.com);](image1)

![Figure 2. Balogo as traditional game of Suku Banjar (retrieve from money.id);](image2)

Figure 3. Experiment design

2.2. Treatment

The learning to facilitate mental modeling must involve modeling cycle as showed in Fig. 4. Modeling cycle consists of five stages: explore the information, create models, test models, evaluate models, and revise models [25]. The teacher’s role is to provide new information to be assimilated by the students' prior knowledge to enable them to make an explanation or prediction. Explanation or prediction is a mental model that will be investigated through computer simulation program. The results of the investigation will be used to evaluate the model that has been created. From the evaluation, students will decide to revise or continue to use the model.
In this research, modeling cycle was integrated into the Problem Based Learning to improve students' mental modeling (showed in Table 1). Problem-based learning was selected because it uses real-world problems as anchor investigations [26][31]. Thus it would be easier for students to form mental models. Students could also be easier to make the explanation and prediction.

Table 1. The integration of cycle modeling in the syntax of problem based learning

| Syntax of PBL                  | Cycle Modeling |
|-------------------------------|----------------|
| Orienting the problem         | Explore        |
| Planning investigation        | Create         |
| Doing the investigation       | Test           |
| Developing and presenting result | Evaluate      |
| Reflecting and evaluating     | Evaluate       |
|                               | Revise         |

2.3. Instrument to Measure Students’ Mental Model

Table 2. Description of test of mental model

| Items                          | Indicator                                         | Infit Mean Square | Outfit t | Reliability |
|--------------------------------|---------------------------------------------------|-------------------|----------|-------------|
| Item 1                         | Describe forces that act on a body                | 0.99              | -0.2     |             |
| Item 2                         | Explain the cause of phenomenon that related with inertia concept | 1.09              | 0.2      |             |
| Item 3                         | Predict the phenomenon that will happen if a force acts on a body | 0.80              | -0.5     |             |
| Item 4                         | Explain daily life phenomenon when a force acts on a body | 1.14              | 0.8      | 0.91        |
| Item 5                         | Explain the motion of a body that related with action-reaction forces concept | 0.89              | -0.2     |             |
| Item 6                         | Predict the motion of a body that related with action-reaction forces concept | 0.89              | -0.2     |             |

The instrument to measure student’s mental model consist of six essay items which related to Newtons’ laws of motion. The question asked student to describe, explain, or predict a phenomenon about force and motion. The first question asked students to describe forces that act on the ball in vertical motion. The second question related with inertia of spinned egg. The third question asked student to predict acceleration of a stroked logo. In the fourth question student must explain why paddle bicycle in ascending road is heavier than paddle in descending road. In five question, the
student were asked to describe the action and reaction forces in a cart pulled by a horse. In last question, the students must be predict the motion that caused by action and reaction forces. These items has been tested to 36 student to determine its validity and reliability. The result was analyzed by QUEST program and the result is shown in Table 2 above. Infit mean square show item’s fitness with rasch model and outfit t indicates item acceptability. Infit mean square has interval from 0.77 until 1.30. In the other side, the outfit t’s interval extends from -2.0 until +2.0.

2.4. The Achievement of Mental Modeling

2.4.1. Normality Test. Normality Test was used to determine the normal distribution of data. Normality test was done with the Shapiro-Wilk test. Normal distribution of data requirements if the probability is less than 0.05.

2.4.2. Homogenitiy Test. Homogeneity test was used to know the research population is homogeneous or not. Homogeneity test carried out by the homogeneity of variance through SPSS Program. The samples research come from a homogeneous population if the probability calculation is greater than 0.05.

2.4.3. Hypothesis Test. Hypothesis in this research include:
Ho: students’ mental modelling postest score in experimental class equal to or less than students’ mental modelling postest score in control class
H1: students’ mental modelling postest score in experiment class overcome students’ mental modelling postest score in control class.
Calculation was done to answer this hypothesis by independent sample t-test in SPSS program. The test criteria: Ho is rejected if sig. value less than 0.05.

3. Result and Discussion

3.1. Result

The result of mental modelling tes are shown in Table 3.

|                           | Control class | Experimental Class |
|---------------------------|---------------|--------------------|
|                           | Pre-test      | Pos-test           | Pre-test | Postest |
| Max score                 | 60            | 80                 | 57       | 90      |
| Min score                 | 20            | 37                 | 23       | 43      |
| Average                   | 37.54         | 59.00              | 40.16    | 70.43   |
| Std dev                   | 10.56         | 11.5               | 9.35     | 12.68   |
| Sig-value in normality test | 0.406   | 0.565              | 0.619    | 0.124   |
| N-Gain                    | 0.341         |                    |          |         |

Table 3. Result of mental modeling test

Independent sample t-test was used to determine differences between students' mental modelling in control class and experimental class. The significance level used was 0.05. The calculation result of t-test showed that sig value is 0.003. This score is below than 0.05. Beside that, the N-gain score of experimental class is greater than N-gain score of control class. These results indicate that mental modelling of students in experimental class is better than the mental modelling of students in control class.

3.2. Discussion

The given daily life problems to learn Newton's laws of motion are about jukung and balogo. The daily life problems make student easier to create mental simulation as part of the mental modeling and making the students understand about the applied concepts [4][5][6][23]. Fig. 5 shows the mental
modeling process in this study. In the learning, students are asked to describe the force on the floating jukung, explain the cause of the jukung to remain motionless when there is no force act on it, and explain why a jukung being slowed down. In the learning of Newton's Second law, students are required to predict the acceleration of two cases of struck logos. In the first case, students predict the acceleration of a logo being hit with two different forces. Whereas in the second case, students were asked to predict the acceleration of two logos with different mass that were hit with the equal force. In the learning of Newton's Third law, students are asked to explain why the person who hit the logo is not pushed back even he also received the equal force as the logo received. The next case is to explain why kelotok can move forward when pulling dozens of jukung, whereas the jukung also pull kelotok with the equal force.

The problems above require students to make explanations or predictions of a phenomenon that related force and motion concept. This activity is part of explore and create phase on the modeling cycle. In explore phase, the students must recall the information and experiences that exist in the brain’s schemata to understand the given problem. Students use the information from previous experiences to explain the problem of jukung and balogo and this is part of create mental model. The students create a mental model though its truth and precision are still in doubt. The main objective is that students can use Newton's law Information already possessed during junior high school to explain a phenomenon.

The conducted investigation aimed to test the truth of students’ mental model. The Phet program from colorado university and flash player programs from interactagram and NSTA are used as

![Figure 5. Mental modeling process](image-url)
idealized forms of Newton's laws so that students can observe them in their ideal form. The investigation of Newton's first law related to the effect of the resultant forces in the tug of war. This probe will produce the concept of "if there is no resultant force on the object, it will remain at rest", "if there is a resultant force on the object, then it will move", and "there is forces act on the resting object ". The second investigation in Newton's first law related to the difference of motion of objects due to mass influences. The concept that students will receive is "the mass will affect to the inertia of an object". The next investigation is the effect of the friction force that stops the motion of the object. The obtained concept is "if the resultant force is zero, then the object will remain in motion", and "the external force stopped the moving object".

The inquiry of Newton's second law related to a robotic simulation that drove a box. The received concept by the students is "the bigger the thrust, the greater the acceleration of the object" and "the greater the mass of the object, the smaller the acceleration of the object". The Newton's third law investigation related to simulations of people who throw snow on ice and sleighs that move when they receive action-reaction forces. The concept that students receive is "the action-reaction force has the same magnitude", "the action-reaction force works on different objects", and "the action-reaction force can produce different effects between interacting objects". The stage is the test phase of the modeling cycle.

The investigation results and discussion questions will guide students to form a mental model that is in agreement with the scientists. Students receive such information through the process of assimilation and accommodation to create a new equilibration phase of Newton's laws of motion. This new understanding will be useful for reviewing student predictions and explanation. If the explanations made at the beginning of the lesson are correct, then the students will receive reinforcement of their mental model. However, if it is incorrect answer, students will revise their mental model. This stage is the evaluate and revise stage of the cycle modeling.

The students' mental model strongly influenced by experience [33]. Student will never see objects that keep moving with no force to stop or seen lighter objects falls slower. The given cognitive conflict will make students hesitate with his own knowledge and can be directed to rebuild on their mental to reduce misconceptions [4]. The Students are asked to make prediction of given problem. Predictions will strengthen students' mental modelling [9][21][34]. Predictions are also trains students to make explanations and causal analysis of scientific phenomena, which is part of the mental modeling [21][22].

The problems must have a connection with the students, based on their experience, and need additional search [27]. The students identify these problems and learn things that are needed to solve them. The use of real-world problems is the teacher's way to make students learn through investigation, asking, and challenging the thinking in accordance with the constructivism learning theory [28][29]. In this model the learner was able to understand the concepts, understand the principles that linking concepts and connecting them with the concepts and principles of others, so it can enhance the conceptual development, and reduce misconceptions [28][32]. PBL emphasizes learning through learning process of physics products when solving the problem. The lessons will reinforce the concepts of physics in the long-term memory of learners because students are not only informed but also interact directly with the concept being studied [28][32].

4. Conclusion
We have described the pretest and postest score of experiemntal and control class. Although the pretest score of the two classes is contiguous, the different condition can be found in the postest score. In the discussion section, we have also explained how the given treatment can improve students’ mental model about Newton’s laws on the jukung and balogo. Based on these results, it can be concluded that the problem-based learning with problems of jukung and balogo is effective to improve student mental model about Newton’s laws of motion. We hope this methods can be applied by other researchers to improve students’ mental model in others context of physics.
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