Physics based learning effectiveness PhET simulation model using Problem Based Learning (PBL) for self-independent learning on material and energy enterprises learners MAN 3 Sleman

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Abstract. This study aims to determine the effectiveness of the use of Phet simulation applications on smartphones Problem Based Learning (PBL) learning models of students' learning independence and the different effects of learning independence. The type of research applied was quasi experiment. Research design used Non-equivalent Control Group Design. The population in this study was all students of class X of MAN 3 Sleman which was divided into 8 classes. The sampling technique used cluster purposive sampling. Both classes were given treatment with the Problem Based Learning model assisted by the Phet application which was installed on each student's smartphone. The average level of learning independence of students in the modelling class after they participated in learning activities included in the good category, and in the implementation, class included in the good category. The significance level shows the numbers in the effective category. So it can be stated that the learning independence questionnaire of both classes was effective, it can be concluded that the Problem Based Learning model assisted by the Phets application is effective in terms of the achievement of the learning independence of students in class X of MAN 3 Sleman in the academic year 2017/2018.

1. Introduction

21st century education has three concepts that have been adapted by the Ministry of Education and Culture of the Republic of Indonesia. The three concepts are 21th century skill [1], scientific approach [2] and authentic assessment [3]. This was also explained in the National Education System Law No. 20 of 2003 Article 1 that "education is a conscious and planned effort to create a learning atmosphere and learning process so that active students develop their potential, so that humans are able to face any changes that occur in their lives and lives" [4]. One science that has an important role in facing 21st century education and science and technology is science.

Physics is part of the science that underlies the development of science and technology. Physics subjects are science that discuss the phenomena and natural phenomena found in everyday life to be able to use information technology in solving problems related to events encountered in life. With the rapid development of technology that uses mobile applications with themes and functions that are
combined in the form of entertainment and lifestyle elements of modern society with all the conveniences provided.

The rapid development of these applications makes us forget about the environment, the interaction between one individual and another decreases. Associated with mobile applications that are very often used by students today in the form of application multiplayer arena games. The results of observations carried out in MAN 3 Sleman showed that the facilities owned by the school were adequate but that underutilized were information and communication technology (ICT) facilities. The availability of this facility can certainly be used by teachers such as electronic learning or E-learning. But in reality teachers have not used these facilities for the learning process. One example of using simulations in physics subjects is Phet.

The results of the research from the PhET media assisted learning model have proven effective in improving the physics problem solving skills of high school students [5]. Learning models in the form of problem-based learning can be taken into consideration by the teacher as an alternative learning in school. Integrating PhET media loaded into smartphones can support problem-based learning skills. The use of the problem-based learning model chosen is problem-based learning.

In a learning process there must be an interaction. Interaction is in the form of interaction between students and students and students and teachers. In that interaction arises various problems in learning. Likewise, in class X MIPA MAN 3 Sleman, there are still many problems when physics learning takes place. Based on observations, most students are less responsible, less initiative, there are still many students who are still dependent on others. The results of these observations indicate a lack of student learning independence.

Independent learning is power in individuals through the process of individualization. Independent learning occurs when students are active in controlling themselves from everything that is done, planning something, evaluating, and strongly reflecting what they have experienced [6]. Independent learning is learning that is done by students freely determining their learning goals, the direction of learning, planning their learning processes, learning strategies, using learning resources chosen, making academic decisions, and carrying out activities to achieve their learning goals [7]. Independent students will make every effort to achieve their learning goals. They will motivate themselves to always be passionate about learning so that the goal is achieved maximally.

The researcher will try to provide an alternative learning model that can provide flexibility for students to build their knowledge and find or apply their own ideas so that they are actively involved in the learning process. One teaching that provides self-learning opportunities for students is a problem-based learning model. Problem-based learning is a learning model that is designed so that students get important knowledge, make them proficient in solving problems, and have their own learning strategies and have the skills to participate in teams. The learning process uses a systemic approach to solving problems or facing challenges that will later be needed in careers and everyday life [4]. According to the problem-based learning model, the problems presented are a real problem that can be seen in everyday life so that it presents physics in more concrete phenomena / problems. To further optimize the problem-based learning model in the classroom, the researchers tried to use the help of learning media. One of the media that can be used is PhET, an interactive media simulation that invites students to learn discovery-based interactive simulations and is used to clarify physical concepts [8]. PhET is loaded into android making it easy to use PhET application mobility itself. By supporting LKPD assistance, it focuses on learning.

Independence is a thing / situation can stand alone without relying on other people. Independence of learning is a process that helps students organize their thoughts, behaviors, and emotions to be successful in their observations. This process occurs when students are directed and the process is directed at obtaining information or skills. To encourage self-learning skills, attitudes are developed, among others (1) regular and neat love, (2) strong desire to master certain skills, (3) thirst for progress, (3) thirst for progress, (4) active, (5) critical thinking, (6) creativity, (7) have goals and targets, (8) discipline in carrying out the schedule of activities, (9) respect for time, (10) enthusiasm for hard work, (11) perseverance, (12) dare to take decision, (13) not dependent on others. Students who have learning
independence have the characteristics of active participation in learning, metacognitive, motivational, behavioral views. 3 indicators of learning independence are: (1) working hard in learning, (2) doing work or assignments independently, and (3) not wanting to depend on others. Based on the understanding of learning independence, it can be concluded that learning independence is an ability possessed by students in active learning activities that are driven by the desire to master a knowledge built by the knowledge that they already have, own initiative and not depend on others. The indicators of learning independence are: 1) active in learning, 2) having an urge to learn, 3) having learning initiatives, and 4) not relying on others.

Table 1. Indicator Self-regulated learning

| Aspect            | SubAspect          | Indicator                                                                 |
|-------------------|--------------------|---------------------------------------------------------------------------|
| Indikator Self-regulated learning | Discipline          | a. Prepare the learning equipment needed before learning                  |
|                   |                    | b. Study regularly.                                                       |
|                   |                    | c. Read subject matter before being taught by the teacher.                |
|                   | Initiative         | a. Add reference to reading books as knowledge enhancers.                 |
|                   |                    | b. Make a work plan in learning.                                          |
|                   |                    | c. Make a summary after learning.                                         |
|                   | Responsible        | a. Always work on tasks that are carried out independently without the help of others. |
|                   |                    | b. Believe in one's own abilities                                         |
|                   |                    | c. Prepare your own stationery.                                           |
|                   | Self-confident     | a. Make your own decisions in matters of learning.                        |
|                   |                    | b. Work on individual tasks independently.                               |
|                   |                    | c. Do homework (homework) assisted by others.                             |
|                   | Motivation         | a. Participate in learning activities.                                    |
|                   |                    | b. Make various efforts in completing learning activities to completion.  |
|                   |                    | c. Ask when there is material that has not been understood.               |

2. Method
Desian research applied is quasi experiment. The study of quasi experiment is the development of a true experiment. In a quasi experiment research is not entirely the researcher is able to control external variables that influence the results. This research was conducted in April 2018 with the first two times taking place in MAN 3 Sleman, Yogyakarta Special Region. The research design uses Nonequivalent Control Group Design. The population in this study were all students of class X MAN 3 Sleman which were divided into 8 classes. The sampling technique uses purposive sampling cluster to obtain X MIA 1 class as the modeling class and X MIA 3 class as the implementation class. Both classes are treated with the Phet assisted Problem Based Learning model that is installed on each student's smartphone. The implementation class was given an additional form of LKPD which was created and validated by experts.

Data collection in this study was conducted by using an independent learning questionnaire to see the effectiveness of using the Phet-assisted Problem Based Learning model. The Phet and LKPD applications that are used as media are validated using the expert judgment method by 2 validity experts.
and 1 subject teacher. The results of the independence questionnaire learn with a scale of 5 and the distribution of scores using category criteria [9]. The research instrument was tested using questionnaire validity test, questionnaire reliability, test validity, and test reliability. The data analysis technique uses two-way variance analysis with cells not the same as the equation 1

\[ X_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \epsilon_{ijk}. \]  

Before analyzing the data, an analysis prerequisite test was carried out, namely the test for normality and homogeneity. For data on learning independence based on the indicators studied. The indicators of learning independence seen in this study are discipline, initiative, responsibility, confidence, and motivation.

3. Results and Discussion

The results of learning independence in the modeling class. The results of the student learning independence questionnaire can be seen through the results of filling out the learning independence questionnaire of students who analyzed using value equations with a scale of 5 as shown in Table 1 below.

| No. | Range Average Score | Category |
|-----|---------------------|----------|
| 1.  | X>3,4               | Very good|
| 2.  | 2,8<X\leq3,4       | Good     |
| 3.  | 2,2<X\leq2,8       | Pretty good |
| 4.  | 1,6<X\leq2,2       | Not good |
| 5.  | X\leq1,6            | Very good |

The results of the work of the learning independence questionnaire for the subject matter of Energy modeling students are presented in Table 3 below.

| No. | Indicator     | Score | Category |
|-----|---------------|-------|----------|
| 1.  | Discipline    | 3,09  | Good     |
| 2.  | Initiative    | 2,86  | Good     |
| 3.  | Responsible   | 3,21  | Good     |
| 4.  | Self-confident| 3,62  | Very Good|
| 5.  | Motivation    | 4,06  | Very Good|
|     | Average       | 3,37  | Good     |

Table 3 shows the average level of learning independence of students in the modeling class after they take part in learning activities with the Problem Base Learning (PBL) learning model based on PhET simulation which is equal to 3.37 which is included in the good category. This indicates that learning using the Problem Base Learning (PBL) learning model based on PhET simulation influences students' learning independence in good categories [10].

Meanwhile, the effectiveness of the learning independence questionnaire in measuring the level of learning independence of students in the modeling class was analyzed using the one-sample t-test in the SPSS program. In testing the level of learning independence of students in this modeling class, the value used in the one-sample t-test is 0. Hypotheses to test the one sample t-test in the modeling class are reviewed as follows:

H\(_0\): the learning independence questionnaire of innovation results is not effective in terms of the achievement of learning independence of the modelling class students.

H\(_a\): learning independence questionnaire results of innovation are effective in terms of achievement of learning independence of the modelling class students.

Mathematically, the two hypotheses can be written as equation 2 and 3

\[ H_0 : \mu \leq 0 \]
The results of one-sample t-test analysis on the effectiveness of the learning independence questionnaire in the modeling class can be shown in Table 3 below.

**Tabel 4. Results of One-Sample t-Test Analysis on the Effectiveness of Learners' Self-Reliance Questionnaire Modelling Classes**

| Test Value = 0 | T | Df | Sig. | Mean Difference | 95% Confidence Interval of the Difference |
|---------------|---|----|------|----------------|------------------------------------------|
|               | 51,022 | 29 | 0.000 | 83,567 | Lower 80.22, Upper 86.92 |

Table 4 shows the significance value equal to 0.00 which is less than 0.05, so H₀ is rejected, meaning that the learning independence questionnaire from the results of innovation is effective in terms of achieving the learning independence of the modeling class students.

**Results of Independence of Learning Implementation Classes.** The results of the students' learning independence questionnaire can be seen through the results of filling the learning independence questionnaire of students who analyzed using the standard value equation with a scale of 5 as shown in Table 4 in the previous section. The results of the work of the learning independence questionnaire for the subject matter of the Energy implementation class students are presented in Table 5.

**Table 5. Learning Outcomes of Students in the Implementation Class**

| No. | Indicator   | Score | Category |
|-----|-------------|-------|----------|
| 1.  | Discipline  | 2.91  | Good     |
| 2.  | Initiative  | 2.87  | Good     |
| 3.  | Responsible | 3.13  | Good     |
| 4.  | Self-Confident | 3.71 | Very Good |
| 5.  | Motivation  | 3.83  | Very Good |
|     | Average     | 3.29  | Good     |

Table 5 obtained the average level of learning independence of students in the implementation class after they joined the learning activities with the Problem Base Learning (PBL) learning model based on PhET simulation which was equal to 3.29 which was included in the good category. This indicates that learning using the Problem Based Learning (PBL) learning model based on PhET simulation affects the learning independence of students in good categories [11].

Meanwhile, the effectiveness of the learning independence questionnaire in measuring the level of learning independence of students in the modeling class was analyzed using the one-sample t-test in the SPSS program. In testing the level of learning independence of students in this modeling class, the value used in the one-sample t-test is 0. Hypotheses to test the one sample t-test in the modeling class are reviewed as follows:

The results of one-sample t-test analysis on the effectiveness of the learning independence questionnaire in the implementation class can be shown in the following Table 6.

**Table 6. The Result of One-Sample t-Test Analysis on the Effectiveness of Questionnaire for Student's Learning Independence in Implementation Class**

| Test Value = 0 | T | Df | Sig. | Mean Difference | 95% Confidence Interval of the Difference |
|---------------|---|----|------|----------------|------------------------------------------|
|               | 53,325 | 29 | 0.000 | 82,300 | Lower 79.14, Upper 85.49 |

Based on Table 6, the sig value is obtained. equal to 0.00 which is less than 0.05, then H₀ is rejected, meaning that the learning independence questionnaire from the results of innovation is effective in terms of achieving the learning independence of the implanted class students.
4. Conclusion

Based on the results and discussion of the study, the conclusions that can be drawn that the PhET-based Problem Based Learning model is effective in terms of achieving learning independence of class X MAN 3 Sleman students in the academic year 2017/2018. (1) Classes are given treatment with the assisted Problem Based Learning model of the Phet application that is installed on each student's smartphone; (2) The average level of learning independence of students in the modeling class after they take part in learning activities is obtained by a result of 3.37 which is included in the good category, and in the implementation class which is equal to 3.29 which is included in the good category; (3) The level of significance of the effectiveness of the learning independence questionnaire of the two classes is 0.00, it can be concluded that the learning model.

Based on the conclusions above, the researchers suggest (1) a PhET-assisted problem-based learning model can be considered by the teacher as an alternative learning in school; (2) PhET-based problem-based learning models can improve student learning independence; (3) Further research examining the effects of the problem-based learning model based on the PhET application on different aspects for more diverse materials as well.

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