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To cite this article: Ratna Sari *et al* 2019 *J. Phys.: Conf. Ser.* **1233** 012030

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The Implementation of Problem-based Learning Model with Online Simulation to Enhance the Student's Analytical Thinking Skill in Learning Physics

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Abstract. The aim of this research is to enhance the student's analytical thinking skill through the implementation of problem-based learning model with online simulation on optical devices subject, especially on a discussion about the eyes. The type of this research is a pre-experimental study. The research design is one group pre-test post-test design. The students who participated in this research were the students of class XI MIPA 4 in SMA Negeri 1 Prambanan Sleman Yogyakarta, Indonesia. The number of sample are 27 students. The sample is taken by using cluster random sampling technique. The test is an essay test about the eyes. The test is validated by expert's judgement. The results of the test validity are valid and feasible to use. The test is used in pre-test and post-test. The result is problem-based learning model with online simulation can enhance the student's analytical thinking skill, but the enhancement is in the low category.

Keywords: Problem-based learning; Online simulation; Analytical thinking skill

1. Introduction

The physics learning activity must be appropriate with the characteristics of physics as natural science [1]. The characteristics include an observing activity, an asking activity, a trying or a collecting data activity, an associating or a reasoning activity, and a communicating activity. These activities are often known as the 5M activity. An associating or a reasoning activity is one of the 5M activity [1]. This activity is aimed to build and to train the student's analytical thinking skill [1]. The student's analytical thinking skill is important because it can drill the reasoning skills, lead to problem solving, and bridge towards the creative ability. It can be said as the basic skill that is needed to develop the high order thinking skills [2].

The fact shows that the student's analytical thinking skill is still in the low category [3], [4]. The facts are: (1) in a research that conducted by Ikhwanuddin explained that the low average score of physics subjects was due to the low analytical thinking skill [3] and (2) from the observation result that conducted by Anwari that explained the average value of multiple-choice test about analytical thinking skill was obtained 69.35 of 100 [4]. The low analytical thinking skill can affect the students' understanding about material. It can make a difficult for the students in the problem-solving process.

Many things can be the cause of the low analytical thinking skill. First, the implementation of the physics learning process is still teacher-centered [5]. Second, the content is not contextual [6], [7]. And, thirdly, the students use the memory-based approach in the physics problem solving activity [8], [9].



The solution to overcome that problem is implementing problem-based learning (PBL) model in the physics learning process. The PBL model emphasizes the learning process to the student using real-world problem approaches [10], [11], [12], [13], [14]. The PBL model consist of 5 stages, that is: (1) orient the problems to the students; (2) organize the students to learn; (3) guide the students in an investigation; (4) develop and present the work results; and (5) analyze and evaluate the problem solving [15]. Through all stages in this PBL model, especially in the third stage, it is expected that the student's analytical thinking skill can enhance.

The developing of information, communication, and technology (ICT) that very rapid can affect the physics learning process. The physics learning process can be presented using instructional media that available in cyberspace. One of instructional media that available in cyberspace is physics online simulation. The use of online features in learning process can improve the student's preparedness and shorten the time that is needed [16]. The benefits of instructional media also to increase the student's engagement in learning [17].

The PBL model can be applied with physics online simulations. The physics online simulations can help the students in visualize an eye. It will facilitate an investigation activity. In this research, physics online simulation that be used is already available in cyberspace, at URL address: <https://www.edumedia-sciences.com/en/media/46-focusing-via-visual-accommodation>.

The rest of this paper is organized as follow: Section 2 describes the proposed research method. Section 3 presents the obtained results and following by discussion. Finally Section 4 concludes this work.

2. Research Method

This section describes the proposed research method

2.1 The type of research

This research is a pre-experimental study [18]. The research design is one group pre-test post-test design [18], is shown in Figure 1.

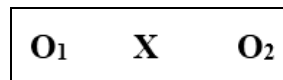


Figure 1. One group pre-test post-test design

Where:

O₁ : pre-test

X : the implementation of problem-based learning model with online simulation

O₂ : post-test

2.2 The place and the time of research

This research takes place in SMA Negeri 1 Prambanan Sleman Yogyakarta. This research is conducted on April 2018.

2.3 The population and the sample of research

The population in this research are all students of class XI in SMA Negeri 1 Prambanan Sleman Yogyakarta, academic year 2017/2018. The sample is taken by using cluster random sampling technique. The class as a sample is class XI MIPA 4 with 27 students.

2.4 The variable of the research

The independent variable in this research is PBL model with online simulation. The dependent variable in this research is the student's analytical thinking skills. And, the intervention variables in this research are the level of the student intelligence, the learning motivation, and the classroom environment.

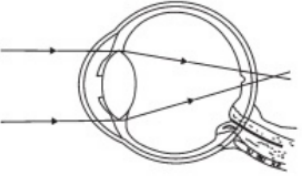
2.5 The technique and the instrument of data collection

The technique of data collection is measurement technique. The data is collected from the results of the pre-test and post-test. The test that is used as a data collection tool is an essay test about the eyes with the cognitive level of Bloom's taxonomy at fourth level (C4). This test consists of 2 questions that is used in pre-test and post-test. The indicators of the test are shown in Table 1 and the test questions are shown in Figures 2 and 3.

Table 1. The indicators of test about the eyes

The question number	The sub question number	Indicator
1 (farsighted/hyperopia)	1.a	The students can analyze the image of eye defect and the data to determine eye defect that is suffered.
	1.b	The students can analyze the image of eye defect and the data to determine the type of lens that is used to overcome the eye defect.
	1.c	The students can analyze the image of eye defect and the data to determine the focus distance of lens.
	1.d	The students can analyze the image of eye defect and the data to determine the power of the lens.
2 (nearsighted/myopia)	2.a	The students can analyze the image of eye defect and the data to determine eye defect that is suffered.
	2.b	The students can analyze the image of eye defect and the data to determine the type of lens that is used to overcome the eye defect.
	2.c	The students can analyze the image of eye defect and the data to determine the focus distance of lens.
	2.d	The students can analyze the image of eye defect and the data to determine the power of the lens.

1. Berikut ini ditampilkan gambar perjalanan sinar pada mata.

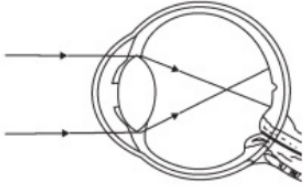


Feri menderita cacat mata seperti yang ditampilkan pada gambar. Dia hanya bisa melihat benda dengan jelas jika jarak benda tersebut 1 meter atau lebih. Berdasarkan gambar dan data yang tersedia, jawablah beberapa pertanyaan berikut!

- Cacat mata apakah yang diderita Feri?
- Kacamata berjenis lensa apakah yang harus digunakan Feri untuk mengatasi cacat mata tersebut?
- Berapa jarak fokus lensa kacamata yang harus digunakan Feri untuk mengatasi cacat mata tersebut?
- Berapa kekuatan lensa kacamata yang harus digunakan Feri untuk mengatasi cacat mata tersebut?

Figure 2. An essay test about the eyes (question number 1)

2. Berikut ini ditampilkan gambar perjalanan sinar pada mata.



Nuri menderita cacat mata seperti yang ditampilkan pada gambar. Dia hanya bisa melihat benda dengan jelas jika jarak benda tersebut paling jauh 2,5 meter. Berdasarkan gambar dan data yang tersedia, jawablah beberapa pertanyaan berikut!

- Cacat mata apakah yang diderita Nuri?
- Kacamata berjenis lensa apakah yang harus digunakan Nuri untuk mengatasi cacat mata tersebut?
- Berapa jarak fokus lensa kacamata yang harus digunakan Nuri untuk mengatasi cacat mata tersebut?
- Berapa kekuatan lensa kacamata yang harus digunakan Nuri untuk mengatasi cacat mata tersebut?

Figure 3. An essay test about the eyes (question number 2)

2.6 The technique of data analysis

The data are obtained from the results of pre-test and post-test. These results are analyzed using the N-gain formula [19] to determine the enhancement of the student's analytical thinking skill before and after the implementation of problem-based learning model with online simulation. The N-gain formula that is used, is shown in Equation 1.

$$N_{gain} = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}} \quad (1)$$

The results of N-gain analysis is categorized into three level is shown in Table 2.

Table 2. The categories of the result of N-gain analysis

The value of N-gain	Category level
$x < 0.3$	Low
$0.3 < x < 0.7$	Medium
$x > 0.7$	High

3. Result and Discussion

This section presented the obtained results and following by discussion

3.1 The results of the test validity

The test is an essay test about the eyes. The test is validated by expert's judgement. The results of the test validity are valid and feasible to use.

3.2 The result of the research

The results of this research are shown in Table 3.

Table 3. The results of student's test

	The result of pre-test	The result post-test
The lowest value	0	18.75
The highest value	50	81.25

The average value	23	46
The enhancement of the average value	23	
The lowest N-gain value	0	
The highest N-gain value	0.75	
The average N-gain value	0.29	

Table 3 above shows that the average N-gain value is 0.29, which it means that the enhancement of the student's analytical thinking skill is in the low category. The category level of the enhancement of the student's analytical thinking skill is shown in Table 4.

Table 4. The category level of the enhancement of the student's analytical thinking skill

The category level	The number of students
There is no enhancement	4
Low	12
Medium	10
High	1

Table 4 above shows that only 1 student is in the high category level. Furthermore, most the students are in the low category level.

3.3 The discussion

The results of data analysis show that the pre-test results are low. Many factors can cause this. One of the factors that can be identified is the students do not understand the material of optical devices, especially the sub-material about of the eyes. This lack of understanding can affect the student's analytical thinking skill.

Furthermore, from the results of data analysis, there is enhancement of the analytical thinking skill. This enhancement is caused by the implementation problem-based learning model with online simulation.

In the implementation of learning, the teacher starts learning by giving motivation to the students about refractive eye surgery with laser light. Then, the teacher orientates the students to a problem. The teacher gives a worksheet to work in groups. This worksheet contains the stages of problem-based learning model.

The students work in groups to solve a problem that is given by the teacher. The problem about the eyes is shown in Figure 4.

Masalah

Andi adalah orang dengan mata normal. Dia dapat melihat jelas meskipun duduk di bangku paling belakang yang berjarak 5 m dari papan tulis. Seiring berjalannya waktu, ia merasakan gangguan pada matanya. Sehingga, ia hanya mampu melihat jelas saat berada di bangku depan yang berjarak jarak 2 m dari papan tulis. Andi kemudian memutuskan untuk berkonsultasi dengan dokter mata. Perkirakanlah bagaimana hasil diagnosa dokter tersebut?

Figure 4. The problem about the eyes

In this case, the teacher also guides the students to formulate a problem. The students begin to identify what problem they are facing. The students must write down some problem formulas.

In the next stage, the teacher guides the students to do an investigation activity. This investigation using online simulation. The online simulation used is available in cyberspace with the web address <https://www.edumedia-sciences.com/en/media/46-focusing-via-visual-accommodation>. The display of online simulation is shown in Figure 5.

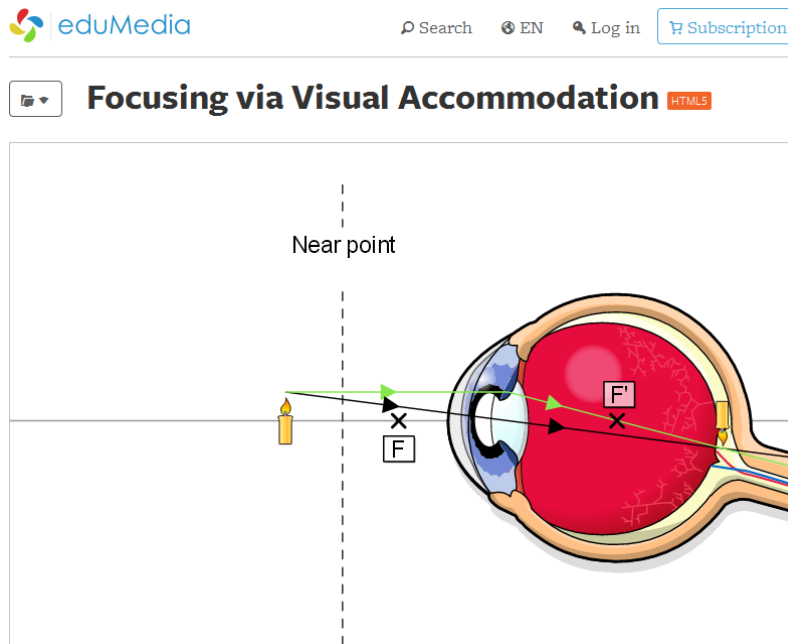


Figure 5. The display of online simulation about the eyes

Through online simulation, the students can:

- 1) observe the parts of the eyes;
- 2) observe the location and shadow of an object that formed on the retina for the normal eyes;
- 3) observe the location and shadow of an object that formed on the retina for farsighted (hyperopia) eyes;
- 4) observe the location and shadow of an object that formed on the retina for nearsighted (myopia) eyes; and
- 5) observe how the eye lenses are swollen and flattened (how the eye lenses to accommodate and do not to accommodate).

In this stage, the teacher guides the students to write the parts of the eyes from an investigation activity and search its function. The teacher asks the students to write many information, include about the normal eyes, the farsighted (hyperopia) eyes, the nearsighted (myopia) eyes, and how the eye lenses are swollen and flattened. After that, the teacher also asks the students to draw the location and shadow of an object that formed on the retina for the normal eyes, for farsighted (hyperopia) eyes, and for nearsighted (myopia) eyes. Some questions about eye defects are presented to train the student's analytical thinking skills. The internet and the related books are used in this activity.

In the next stage, the students are asked to:

- 1) identify the concept of the point focus of lens;
- 2) identify the concept of the object distance and the shadow distance in the sub-material about the eyes; and
- 3) identify the concept of the near point and distant point of the eyes.

In this case, the students practice formulating the relationship between concepts. Then, based on that formulation, the students analyse the problem and solve it. At this stage, the student's analytical thinking skill is enhanced. The students solve the problem and communicate it to other students in the front of the class. At the end of this learning, the teacher evaluates the problem solving that has been presented by the students.

The results of post-test show there is an enhancement in the average value. But that enhancement is in the low category. The lowest enhancement is 0. It can say there is no enhancement. This incomprehension is caused by the students are less serious and less active in learning [3], [4].

The analysis result of the student answer sheet shows that the students has difficulty in analyzing the concepts. The students cannot distinguish:

- 1) the concept of the point focus of lens;
- 2) the concept of the object distance and the shadow distance; and
- 3) the concept of the near point and distant point of the eyes.

When the students meet some trouble, they are reluctant to ask the teacher. Likewise, when the teacher asks the students "there is a problem?", most of the students are silent and others answer that they understand. The analysis result of the student answer sheet also shows that the students incorrectly analyze concepts and relationships between concepts. Therefore, the analysis and calculation to solve the problem of eye defects (related to the calculation of the focus distance and the dioptric value of the eye glass) is also incorrect.

In the results of the data analysis, there is an enhancement of the student's analytical thinking skill with N-gain value 0.75. It is in the high category level. In this case, the student can analyze the concepts. The student can also use the relationships between concepts in solving problems.

Overall, it can be seen from the average N-gain value, the enhancement of the student's analytical thinking skill is in the low category. It can be said that the problem-based learning model with online simulation can enhance the student's analytical thinking skill, but the enhancement is still low. Some of the things that cause are:

- 1) the student's' abilities; and
- 2) the students not familiar with the problem-based learning model, so that, the students are not serious in learning.

The limitation in this research is online simulation access often not responding even though an internet signal amplifier has been used. So that, this implementation takes a long time.

4. Conclusion

This paper has presented an enhancement the student's analytical thinking skill through the implementation of problem-based learning model with online simulation on optical devices subject. Based on the results of data analysis, the conclusion in this research is the implementation of problem-based learning model with online simulation can enhance the student's analytical thinking skill, but the enhancement is still low. Most of the students are in the low category level and only 1 student is in the high category level. Although the enhancement of the student's analytical thinking skill is relatively low, the problem-based learning model with online simulation is well applied because through this learning can train the students to identify the concepts and formulate the relationships between concepts. For the next research, internet networks and management of learning time need to be considered. In this case, it is recommended to conduct an introductory learning classically. After that, the problem-based learning model is implemented in the classroom in learning physics.

Acknowledgement

This research is fully supported by Graduate Program, Yogyakarta State University.

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