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Physics Learning with E-Book Using Problem Based Learning (PBL) Model to Improve Image Representation Ability of High School Students on Optical Material

M. F. T. Nirmala[1*], D. A. Gebze[2], A. M. R. Tumanggor[3], M. Lengkong[4], I. Wilujeng[5]

[1 2 3 5] *Physics Education, Graduate School, Universitas Negeri Yogyakarta, Sleman, Indonesia*
[4] *Educational Research and Evaluation, Graduate School, Universitas Negeri Yogyakarta, Sleman, Indonesia*
[*] *Corresponding author. Email: maria0020pasca.2018@student.uny.ac.id*

ABSTRACT
This research aimed to (1) produce learning tools and e-book media using Problem Based Learning (PBL) model to improve image representation ability on optical material of class XI MIPA students at SMAN 1 Banguntapan; (2) know the effectiveness of e-book learning media in physics learning activities using PBL model; (3) find out the improvement of image representation ability of students at SMAN 1 Banguntapan. This research was a developmental research with the 4D model. The results showed that (1) learning tools and e-book media using PBL model were appropriate to be used in physics learning activities. (2) e-book learning media was effectively used in physics learning. (3) improvement on the students' image representation ability increased significantly.

Keywords: *E-book, Image representation, optical material.*

1. INTRODUCTION

Representation is a way of expressing something or a concept, in the form of pictures, graphics, symbols, verbal, and others. Bal [1] states that the types of representations are visual, verbal and mathematical representations. This type of representation requires each ability to solve problems [2]. Visual representation, for example, requires the ability of visual representation to solve problems presented in visual form. A more concrete representation can make it easier for students to understand abstract concepts, for example students can use free body diagrams to determine the force components to construct Newton's law II [3]. The ability of diagrammatic and argumentative representation was able to improve the students' understanding of Newton's Law concepts [4].

Multi-representation plays three main roles in learning to complete and construct an understanding of concepts; representations to support and complete existing information or existing cognitive processes, representations as constraints of interpretation, so that no misconceptions occur on students, and representations are used to build a deeper understanding of certain concepts [5]. In order for the use of representations to be useful, students also have to be skilled in making choices in the use of representations in solving a problem. If students do not have this ability, multi-representation can be a detrimental effect on problem solving in learning [6].

Visualization makes it easy to convey natural phenomena that cannot be seen directly. Students prefer to represent problems in the picture rather than other forms of representation [7]. Image representation helps visualize abstract objects such as describing the condition of the force in the system [8]. An approach that is closer to reality makes it easier for students to understand the problem in a shorter time. Fisher [9] states that the use of free body images can improve the ability to formulate

equations in object motion. Students who have low problem solving skills tend to solve problems by entering or replacing values into equations without interpreting their meanings, so the solutions given are not appropriate [10]. Development of the ability to represent this image can be done at every opportunity in learning, such as the selection of learning resource media that support the presentation of image representation.

Common problem in learning today is the use of textbooks as the only source of learning used by students. Although it is always revised based on the curriculum, the book content does not offer much motivation and also exercises that emphasize the use of plural representations [11]. Students have difficulty in reading and interpreting images used in textbooks [12][13].

The ability to solve problems is very important in physics learning [14]. There was a positive relationship between the consistency of the use of representation, understanding of concepts and scientific reasoning [15]. Representation can be a factor of competence in relation to conceptual understanding and scientific reasoning. This is supported by the definition of representation which is a process that states the scope and direction of the problem and regulates the knowledge needed in problem solving [16]. The ability of students to solve problems depends on their ability to understand each problem presented. After representing the problem, students then think of ways to solve the problem, then solve the problem, evaluate problem solving, and finally the problem is solved.

The concept of physics in general is abstract and theoretical. These concepts are needed in an explanation to understand certain phenomena and it is not enough if presented in the form of static images only. For example, the process of shadow's formation when looking at objects on optical material [10]. The process is not enough if illustrated through a static image. Therefore, there is a need for media that can present it in the form of moving or dynamic images.

E-book is a book in electronic format. The use of electronic media makes e-books environmentally friendly because it can reduce paper usage. E-books are one of the supporting media as a source of learning in learning activity. E-books can be downloaded to a computer or smartphone so that they are easier to use. E-books are effective in improving the process and learning outcomes [17] [18]. E-books have more flexible, attractive, environmentally friendly features, provide attractive graphics, enlarged text sizes and present audio and video. Learning becomes fun and interactive with these features [19].

2. RESEARCH METHOD

This research involved 60 students of class XI in second semester. This research was conducted at SMA Negeri 1 Banguntapan in March until June 2019, in class XI MIPA with specialization in Mathematics and Natural Sciences. MIPA is an abbreviation of Matematika dan Ilmu Pengetahuan Alam, which is commonly used in Indonesia. In this research, the classes used consisted of two classes. The number of students in each class was 30 students. Class XI MIPA 1 was a modeling class and class XI MIPA 2 was an implementation class.

The research method used was the developmental research (R&D) method. This research adapted the 4D model (Define, Design, Development, Disemination). The define stage includes four steps, namely the needs analysis, student analysis, curriculum analysis and concept analysis. The purpose of the define stage is to analyze the needs, materials, students, and the curriculum. The design stage consists of preparing test standards, determining learning media, and choosing the format of teaching materials and a location for the duration of learning and the number of face-to-face meetings based on the breadth of the material. The development stage is the development of learning tools and media, conducting assessments by experts or validation, making revisions, implementing in modelling classes, and implementing in implementing classes. Implementation of learning tools and e-book media is carried out in the modelling class and the implementation class. Implementation in the modelling class was learning activity done by researcher. Implementation in the modelling class was carried out in class XI MIPA 2 with a total of 32 students. While the implementation in the implementation class was learning activity done by the subject teacher in class XI MIPA 1 with a total of 32 students. Dissemination stage is the final stage of research. The purpose of dissemination is to disseminate research products or learning tools and e-book media. This dissemination includes application in other classes, other schools and published in scientific journals. The stages of the research carried out can be seen in full in Figure 1.

The purpose of the development is to produce instruments and learning media e-book that can improve the ability of image representation of class XI MIPA students at SMAN 1 Banguntapan that is valid and reliable. Therefore, the instruments and media developed must meet valid and reliable requirements and their eligibility.

The instruments developed included syllabus, lesson plan, material in e-book, student assessment and test questions on the ability to represent images, whereas the media developed was an e-book. The results of the validation of the syllabus, lesson plan, student assessment, and representation ability test instruments, as well as the appropriateness assessment of the e-book media were analyzed using descriptive analysis [19]. The validity of the product was determined using the Aiken V equation [20] [21][22].

$$V = \frac{\sum s}{\left[n(c-1)\right]} \quad (1)$$

Description: s = r – lo; n = number of panels of assessors; c = highest validity assessment; lo = lowest validity assessment; r = the number given by an assessor. With the criteria as in the table [23] with the number of validators 2 people in five categories.

Table 1. Scoring criteria of validation analysis results using Aiken V

Score Range	Category
0.76 < V ≤ 1.00	Very good
0.59 < V ≤ 0.76	Good
0.41 < V ≤ 0.59	Quite Good
0.24 < V ≤ 0.41	Bad
V ≤ 0.24	Very Bad

The next step was to determine product reliability. Reliability was determined from empirical data on the ability of image representation with the number of test questions of 8 items with dichotomous scoring. Reliability estimation was done in both classes, which were the modeling class and the implementation class. Estimated reliability using Kuder Richardson-20 (KR-20). The instrument is said to have good reliability if the reliability coefficient is ≥ 70 [24].

The feasibility of e-book was also determined by students' responses to the use of media. Students' responses were collected using a questionnaire with Guttman scaling. Student questionnaire responses consist of questions that can be classified into several criteria, namely the clarity of the format, language, presentation of material, pictures and symbols, and illustrations. Analysis of student questionnaire responses by calculating the percentage of answers "Yes".

$$K = \frac{Number\ of\ score\ of\ answer\ "YES"}{Number\ of\ questions}\ x\ 100\ \% \quad (2)$$

Where K is the percentage of eligibility. E-book that was developed are said to be feasible if they obtain a percentage of ≥ 61% [25].

To test the improvement of image representation ability by analyzing the value of pre-test and post-test. Data analysis used descriptive analysis and inferential statistics and the Sign Test with a significance level of 5% through the normality test first.

3. RESULT AND ANALYSIS

The first stage in this research is define stage with the aim to define the results of observation and interviews. The results of the needs analysis showed that the main media of learning resources for students are books. One of the main materials learned by class XI students was optical devices. Optical instrument material was learned at the end of the odd semester. In addition, aspects of multi-representation and representation abilities were rarely measured. The results of the analysis of students of class XI MIPA SMAN 1 Banguntapan showed the average was in the age range of 16-17 years. This age is at the stage of abstract, idealistic and logical cognitive development. The curriculum used was the 2013 curriculum. The results of curriculum analysis were indicators of learning optical instrument materials. Learning indicators included explaining the anatomy of the eye and its function in formation of shadow in the eye, explaining the process of formation of shadow in the eye, identifying and differentiating the formation of shadow in people with eye defects, analyzing the magnitudes associated with optical devices. The results of concept analysis were in the form of concept mapping on optical instrument materials. In addition, determine the material needed during the learning process.

The second stage in this research is design stage. Based on the results of the analysis of concepts and students, the researcher decided to use the e-book media as a learning media, with the Problem Based Learning (PBL) model. Therefore, the draft syllabus, lesson plan, and student assessment format used the PBL model. The e-book media contains optical instrument material. Presentation of content material based on PBL steps.

From the results of the analysis of the breadth of the material, then the allocation of learning was determined to be 3 times face to face. One time face to face with a duration of 90 minutes. The results of the analysis of image representation ability on optical instrument material, then the specifications of the image representation ability tests were formulated by indicator: scanning images systematically and completely, linking variables presented through images, or vice versa, interpreting the data presented in the form of images, interpreting the data presented in the form of images.

The third stage in this research is development stage. This stage aims to develop learning tools and media based on the initial design. The tools developed were syllabus, lesson plan with PBL model, student assessment with PBL model, e-book media and test questions on image representation ability. Furthermore, the device was validated by experts and practitioners. Validators involved in this stage were one expert lecturer and 2 teachers as practitioners. The validation results were then revised. The revision of the validation results was only on typography and writing aspects on the e-book media. The results of the validation by 3 validators then analyzed using Aiken V. The results of the validation analysis of the learning tools and learning media can be seen in table 2.

Table 2. Results of validation analysis of learning tools and e-book using Aiken V

No	Item rated	Validity	Category
Lesson Plan with PBL Model			
1	Subject's identity	0.89	Very good
2	Indicator formulation	0.78	Very good
3	Formulation of learning objectives	0.78	Very good
4	Selection of material, media and learning resources	0.78	Very good
5	Learning model and scenario	0.78	Very good
6	Assessment	0.89	Very good
The Validity of the Lesson Plan with PBL Model		0.81	Very good
E-book Media			
1	Component	0.89	Very good
2	Typography	0.56	Good
3	Conformity of material preparation with PBL model	0.89	Very good
4	Clarity of words and spelling	0.89	Very good
5	Image and coloring	0.89	Very good
E-book Media Validity		0.82	Very good
Student Assessment with PBL Model			
1	Didactic aspect	0.89	Very good
2	Material in Student Assessment	0.78	Very good
3	The suitability of Student Assessment with PBL model	0.78	Very good
The validity of Student Assessment with PBL Model		0.81	Very good
The ability of image representation test			
1	Compliance with the picture representation indicator	0.78	Very good
2	Compliance with learning indicators	0.78	Very good
3	Image and language	0.78	Very good
4	Scoring	0.78	Very good
The validity of the image representation ability test		0.78	Very good
The validity of the e-book media instruments using PBL model		0.81	Very good

The results of the calculation of the average validity of learning tools and e-book media were included in the excellent category. Therefore, it can be concluded that the learning tools and e-book media that are developed meet valid criteria.

The next step is to analyze the reliability of the test instrument for image representation ability. The total test questions on the ability of image representation were 8 items, with dichotomous scoring. Estimated reliability using Kuder Richardson-20 (KR-20), amounting to 0.71. Thus, the test of image representation ability has good reliability.

After conducting a feasibility analysis, learning instruments and media were then applied in the modelling class and implementation class. Application in the implementation class was carried out by modeller/researcher. While the application of research instruments and media in the implementation class was carried out by the physics subject teacher. The purpose of applying in the modelling class was so that physics subject teacher can see and know how to use instruments and media developed in this research.

The learning media e-book contains optical eye material. Just like an ordinary textbook, however e-book have advantages in the presentation of material and some additional features such as animation and video of the process of formation of shadow in the eye. E-books were distributed to each student's cell phone, so students can use it as a source of learning during learning activity. The use of e-book media was done in stage 1, stage 3, and stage 5 in the problem based learning model. Stage 1 in the problem based learning model, students were directed to identify the problems presented in the e-book. In stage

3, students were directed to conduct an investigation based on the student assessment available in the e-book. In stage 5, students analyzed and evaluated the problem solving process by comparing the results of the investigation with the concept of how optical devices are available in the e-book. was higher than 60%, then the e-book is feasible to use. Next was the analysis of the results of the pre-test and post-test of the students' image representation ability in the modelling class and the implementation class. The achievement of the average pre-test and post-test can be seen in the picture.

Table 3. Recapitulation of the results of student responses analysis to e-books

No	Criteria	Percentage of modeling class	Category	Percentage of Implementaion class	Category
1	Clarity of e-book formats	88%	Very good	84%	Very good
2	Linguistic	81%	Very good	84%	Very good
3	Presentation of material, pictures and symbols	84%	Very good	81%	Very good
4	Illustration	78%	Very good	75%	Good
Total		83%	Very good	81%	Very good

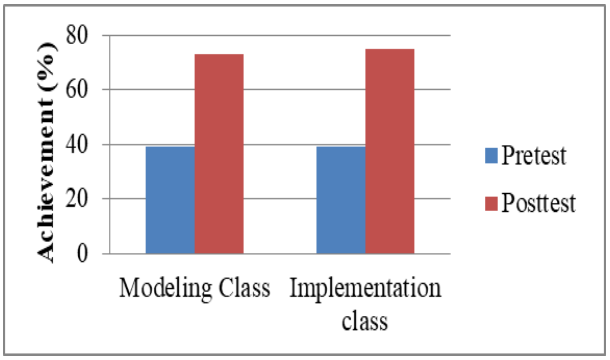

Figure 1. Achievement of the average pre-test and post-test scores of image representation ability in the modelling class and the implementation class

The e-book media was used as a learning resource for students. One of the advantages of e-books is the flexibility in presenting learning resources. The e-book was equipped with other links related to optical devices material. Flexibility can make students able to read related material easily, anytime and anywhere, outside of learning.

Then the analysis of the student response questionnaire was conducted. The student response questionnaire was distributed at the end of the third session. Student response questionnaire aimed to determine student responses to the e-book media that have been used in learning activity. Students who filled in the student questionnaire responses were as many as 32 students in the modelling class and 32 students in the implementation class. Therefore, a total of 64 students filled out the questionnaire. Recapitulation of the results of student responses analysis can be seen in the table 3.

Based on the results of the analysis of student questionnaire responses, it was known that the percentage of each criterion and the percentage of total

From the Figure 1, it can be seen that the average achievement of pre-test in the modelling class was 39%. After applying the instrument and PBL e-book media, the average achievement of the post-test of image representation ability in the modelling class increased to 73%. In the implementation class, the same thing happened where the average achievement before applying the instrument and PBL e-book media was 39%. After applying the instrument and PBL e-book media increased by 75%.

Table 4. The results of the descriptive analysis of the pre-test and post-test values of image representation ability of the modeling class and the implementation class

Descriptive Statistics

	N	The mean	Std. deviation	Minimun	Maximum
Pre-test modeling class	32	3.16	0723	1	4
Post-test modeling class	32	5.88	0833	4	7
Pre-test implementation class	32	3.13	0.793	2	5
Post-test implementation class	32	6.03	0.861	4	7

Table 5. Wilcoxon signed ranks test of image representation ability of modeling class and implementation class

Ranks

		N	Mean Rank	Sum of Ranks
Post-test modeling class – pre-test modeling class	Negative ranks	0 [a]	0.00	0.00
	Positive Ranks	32 [b]	16.50	528.00
	Ties	1 [c]		
	Total	32		
Post-test implementation class – pre-test implementation class		0 [d]	0.00	0.00
		32 [e]	16.50	528.00
		0 [f]		
		32		

a. Post-test modelling class < Pre-test modelling class
b. Post-test modelling class > Pre-test modelling class
c. Post-test modelling class = Pre-test modelling class
d. Post-test implementation class < Pre-test implementation class
e. Post-test implementation class > Pre-test implementation class
f. Post-test implementation class = Pre-test implementation class

Table 6. Wilcoxon signed ranks test of image representation ability of modeling class and implementation class

Ranks

		N	Mean Rank	Sum of Ranks
Post-test modeling class – pre-test modeling class	Negative ranks	0 [a]	0.00	0.00
	Positive Ranks	32 [b]	16.50	528.00
	Ties	1 [c]		
	Total	32		
Post-test implementation class – pre-test implementation class		0 [d]	0.00	0.00
		32 [e]	16.50	528.00
		0 [f]		
		32		

a. Wilcoxon Signed Rank Test
b. Based on negative ranks

Next was the analysis of the results of the pre-test and post-test of image representation ability. Analysis of the pre-test and post-test scores was carried out using descriptive analysis and the Sign Test in SPSS Software. The results of the analysis of the pre-test and post-test value can be seen in the table 4.

Descriptive analysis results showed the average post-test score was higher than the pre-test in the modelling class and implementation class. The minimum score of correct answer of pre-test in the modelling class was 1 and the post-test was 4. While the maximum score of correct answer of the pre-test in the modelling class was 4 and the post-test was 7. In the implementation class, the minimum score of correct answer in the pre-test was 2 and the post-test was 4. While the minimum score of correct answer in pre-test on the implementation class was 5 and the post-test was 7.

Based on Wilcoxon signed ranks test data for implementation and modelling classes showed that there were no students whose post-test value was smaller than the pre-test. Positive ranks indicated that there were 32 students who had a post-test value higher than the pre-test. Ties on modelling class revealed that there was one student who had the same pre-test and post-test scores.

Statistical Test results showed that the calculated Z value of the modelling class and implementation class with p value (Asymp. Sig. 2-tailed) was less than the significance (5%), it can be concluded that there was a significant increase in post-test score. This means that the e-book media with the PBL model used can improve students' image representation ability.

The results of the analysis of the pre-test and post-test scores in the modelling class and the implementation class indicated that the use of e-book media with PBL model as learning resources can improve the students' image representation ability. Students' ability to understand images, and understand the relationship between variables in the picture affected learning outcomes. Students with good image representation ability, has a good learning outcome, because the representation serves as a tool to help solve problems in physics [26][12] and make it easier to understand and explain certain phenomena [10][27][28].

The results classically showed that the image representation ability of students in the modelling class and implementation class improved after using instruments and e-book media with PBL model as learning resources. But individually, there were students who have not yet completed. In the modelling class there were students who had the same post-test score with the pre-test.

4. CONCLUSION

The results showed that the learning tools and e-book media using PBL models were appropriate to be used in physics learning activities on optical material. This was proven by the acquisition of validity scores using Aiken V, the results of student responses, and the reliability analysis of test questions using KR-20, which was valid and reliable. The e-book learning media was effectively used in physics learning on optical material. This was proven by the results of the Wilcoxon signed ranks test on the modelling class and the implementation class. Students' image representation ability improved significantly, as proven by the average achievement of the pre-test and post-test scores in the modelling class and the implementation class increased; Wilcoxon signed ranks test. In addition, it was proven by the post-test mean value that was higher than the pre-test mean value in descriptive analysis

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