# The development of PBL e-handout assisted by PhET simulation of optical material-lenses for high school students

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**Abstract**, Technology is very important in learning, particularly in learning physics. This paper aims to determine the feasibility of e-handout PBL-aided simulations PhET. The development of the e-handout is in accordance with the ADDIE development model which is validated by the validator team. E-handout developed with simulations PhET and included in the virtual classroom Schoology can be accessed on a laptop that can be used as teaching materials to help students explore the concepts of physics.
**Keywords**: *e-handout, PBL, PhET*

## 1. Introduction

The Industrial Revolution has changed the way human labor from manual to automation or the use of digitization [1]. It is important to realize that the industrial application of 4.0 in education cannot be done suddenly, but rather is a gradual change [2]. The period of the fourth industrial revolution will be marked with full automation and digitization process, and the use of electronic and information technology (IT) in manufacturing and services in a private environment [3], [4]. The information technology revolution led to a rapid expansion on each side of the modern world and become the most important requirement in the development of instructional media for schools, universities and other educational institutions [5].

Technology is very important in learning, particularly in learning physics. Physics is part of science [6] is one of the disciplines that is growing rapidly, both in terms of material and its use [7]. Physics is the science that studies the nature and regularity events. Physics is one of the lessons are less desirable, one cause is physics has many abstract concepts [8].

Learning that is still teacher-centered causes students to be less active in the learning process, physics learning outcomes are low compared to other natural science subjects, and student activities to take notes are still lacking. One form of teaching materials is a handout. Handout introduced to the students as an introduction before the learning begins, so that students become more prepared and motivated. Handouts containing material that is short, dense yet clear, equipped with educational games and evaluation questions that encourage students to think systematically [9], [10]. The learning model chosen was PBL [6,11]. Through the PBL model, students can be trained to learn independently and solve problems. So that it can improve thinking skills and invite students to be directly involved actively in the learning process [6], [12-14]. Students tend to learn according to their daily experiences [15].

Along with the rapid development of science and technology, electronic media can be a solution to the obstacles encountered by educators and students when learning with material content that is abstract. Experiments that are difficult to carry out in real laboratories, which are generally due to the lack of adequate laboratory tools, can be carried out using virtual laboratory media that are run with computers. One of the virtual laboratory applications is Physics Education Technology (PhET) simulation. The PhET Team explained that PhET is a site that provides simulations of learning physics, biology, chemistry, and mathematics, which are provided free of charge by the University of Colorado for the benefit of classroom learning or can be used for individual learning purposes. The simulation is designed interactively so that users can learn directly [16]. The optic-lens material was chosen because it is not possible to conduct real experiments in a school laboratory due to the unavailability of required equipment [17]. So it is used as a virtual laboratory with a PhET simulation.

Application of electronic technology for learning that e-learning to deliver learning in the form of computer technology, the Internet and other electronic technologies. The use of e-learning can provide learning experiences of students, experience in using technology and information is growing. One e-learning is developed using an application that is Schoology. During this learning in schools Digital Simulation done conventionally, consequently less motivated learners and low learning results. When applied to e-learning-based Schoology learners tend to be more motivated and increased cognitive achievement seen from the study [8], [18].

Schoology innovative platform built on inspiration from Facebook (interface and model, with the presence of the fundamental aspects of post, status updates, sharing and instant update) and with the precise aim to be a learning tool. Some of the advantages of Schoology, among others: a) Schoology provides more options resources. b) Schoology can accommodate the type of question (question bank) to be used when a quiz. c) Schoology facilities attendance used to check student attendance. d) Schoology also provides analytics to see all the activity of students in each course, assignments, discussions and other activities that are prepared for the students [5], [15]. Blended learning based on Schoology can be a solution to overcome the learning process that requires a lot of theory. Blended Learning based on Schoology is learning that combines face-to-face learning in class and online learning using the Schoology application outside of school hours [19].

Therefore, this study aims to develop e-handout PBL-aided simulations PhET as supporting learning the subject matter physics optics - lens magnifier camera and microscope for High School Students. The benefits of development that can be used as a source of learning that can motivate students to learn physics and can be used as a medium for independent learning for students.

## 2. Research method

Data used in this developmental research is qualitative and quantitative. Qualitative data is taken from the advice of a team of expert validation, while quantitative data is taken from a questionnaire validation of subject matter experts, media experts and peers. Data obtained from the development of this product is used as a basis in determining the feasibility of e-handout. The instrument used in this study was a questionnaire. Questionnaire compiled in this study was a questionnaire validation of subject matter experts, media experts and peers. instrument set using Guttman scale with two choices of answers are yes and no.

Qualitative data in the form of criticism and suggestions from experts and colleagues collected and used to guide the improvement of e-handout. Analysis of questionnaire data validation is performed on a validator feedback score obtained from every aspect tabulated and the average score is calculated. As reference the data were analysed using percentages [20];

$$P = \frac{f}{n} \times 100\% \quad (1)$$

Where; $(P)$ is Percentage, $(f)$ is frequency, and $(n)$ is the total number of frequencies.
Furthermore, the length of the interval specified grade in each category consisting of five categories, grouping the values in each category are presented in table 1.

**Table 1.** Category rating.

| No. | Interval % | Category |
|---|---|---|
| 1 | $80.01 \geq x \leq 100$ | Very good |
| 2 | $60.01 \geq x \leq 80.00$ | Good |
| 3 | $40.01 \geq x \leq 60.00$ | Enough |
| 4 | $20.01 \geq x \leq 40.00$ | Deficient |
| 5 | $0.00 \geq x \leq 20.00$ | Bad |

This type of research is the research and development (Research and Development). Development model used is the ADDIE model of the analysis, design, development, implementation and evaluation. The study was limited to the implementation step. Research conducted at SMAN 1 Sleman in April 2019. From the observation with the teacher of physics, the research subjects using XI MIA 3 and 5 of 60 learners. Procedure development of teaching materials in the form of e-handout PBL-aided simulations PhET the optical material is only limited to the development phase.

The first step is an analysis to determine the main problems of the performance gap that occur in the explanation and recommend the right solution for the existing conditions. At this stage includes analyzing the curriculum, research, and students. The second step is design, at this stage after analyzing the curriculum and lessons is designing the design of learning activities, and making an e-handout feasibility instrument, so that the e-handout can be designed accordingly and precisely. The third step is development; at this stage, the e-handout is made following the validation results of the e-handout instrument, designing learning activities, and instruments validated by the validation team.

## 3. Results and Discussion

E-handout assisted PBL lesson material physics simulation PhET optical magnifier lens camera and microscope was designed and developed based on the stage of preliminary observations have been conducted in SMA Negeri 1 Sleman arrive at the design stage. The design and content of the e-handout is equipped with optical-lens material and worksheet with syntax PBL learners who are already connected with PhET simulations. So in later learning learners will be able to directly access online PhET simulations contained in the e-handout LKPD. e-handout designs can be seen in figure 1 and figure 2.


**Figure 1.** The cover of the e-handout.


**Figure 2.** LKPD e-handout.

After the design phase, e-handout still in the form of word format are converted to a PDF format to facilitate later be included in a virtual classroom Schoology. To adjust what students need to what has

been developed, validated as much as 3 times. Validation is done is validation media expert, material expert validation and validation of peers. Validator will provide advice, criticism of electronic e-handout developed. Validation is done validator states that the e-handout has been feasible to use the revision of the advice given by the validator.

Used media expert validation criteria cover design aspects of e-handout as much as 7 sub-aspects and design aspects of the content of the e-handout as many as 13 sub-aspects. So that the number of statements used in the validation sheet media is as much as 20 sub-aspects. Media expert validation results are presented in table 2.

**Table 2**. Validation expert media.

| Aspect | Percentage % | Category |
|---|---|---|
| Cover design E-handout (Cover) | 100% | Very good |
| Design Contents E-handout | 100% | Very good |

Table 2 shows the score acquisition validation by media experts based on each aspect. Can be seen in table 1 in the first aspect of Cover Design e-handout (Cover) after the sum obtained total score of 7 points. Scores are then averaged to obtain the right percentage of 100% were categorized as very good based upon the assessment criteria. The second aspect is the design of Contents e-handout. Having obtained summed total score by 13 points. The score is then averaged to obtain a percentage of 100% which is considered very good. The advice given by the corresponding validator of media validation is in the "Letter used again enlarged in order to further highlight the title of the e-handout". Based on the results, it can be seen that the components of the e-handout overall assessed by expert media showed excellent results. Thus, it can be concluded that the e-handout feasible and can be tested in the next stage.

Validation of used material expert feasibility to the feasibility aspects of the e-handout as much as 8 sub-aspects and feasibility of e-handout presenting a total of 14 sub-aspects. So that so that the number of sub-aspects that are used in the validation sheet material is as much as 22 aspects. Matter expert validation results are presented in table 3.

**Table 3.** Validation expert content.

| Aspect | Percentage % | Category |
|---|---|---|
| Feasibility of Contents E-handout | 100% | Very good |
| Feasibility Presentation E-handout | 100% | Very good |

Table 3 shows the score acquisition by subject matter experts based on each aspect. Can be seen on the first aspect of the feasibility of the contents of e-handout after the sum of all sub-aspects obtained a total score of 8 pawns. Scores are then averaged to obtain the right percentage of 100% were categorized as very good based upon the assessment criteria. The second aspect is the presentation of the feasibility of e-handout. Having obtained summed total score by 14 points. The score is then averaged to obtain a percentage of 100% which is considered very good. Advice given validator is using physics formulas in the e-handout more attention again that there are no typographical errors. The advice given by the validator will be used as a material revision before e-handout tested to learners. Based on the results, it can be seen that the components of the e-handout overall assessed by subject matter experts showed excellent results. Thus, it can be concluded that the e-handout feasible and can be tested in the next stage.

Validation involves 6 validator peers is a graduate student of physics education. This validation using the four aspects of assessment include; cover design e-handout as much as 7 sub-aspects, the aspects of e-content design as much as 13 sub handout feasibility aspects of e-handout contents as much as 8 sub-aspects and feasibility of e-handout presenting a total of 14 sub-aspects. So that so that the

number of statements used in the validation sheet colleagues are as many as 42 sub-aspects. A peer validation results are shown in table 4.

**Table 4.** Results of validation peer friend.

| Aspect | Percentage % | Category |
|---|---|---|
| Cover design E-handout (Cover) | 92.86% | Very good |
| Design Contents E-handout | 98.72% | Very good |
| Feasibility of Contents E-handout | 100% | Very good |
| Feasibility Presentation E-handout | 100% | Very good |

Table 4 shows the score acquisition validation of peers as much as 6 validators is based on each aspect. Can be seen on the first aspect of e-handout cover design (cover) after the sum obtained total score as much as 6.5 points. Scores are then averaged to obtain the right percentage of 92.86% which is considered very good based upon the assessment criteria. The second aspect is the design of the e-handout. Having obtained summed total score as much as 12.8 points. The score is then averaged to obtain a percentage of 98.72% which is considered very good. The third aspect is the feasibility of the contents of the e-handout after the sum of all sub-aspects obtained a total score of 8 pawns. Scores are then averaged to obtain the right percentage of 100% which is very good categorized based upon the assessment criteria. The fourth aspect is the presentation of the feasibility of e-handout. Having obtained summed total score by 14 points. The score is then averaged to obtain a percentage of 100% which is considered very good.

After completion validated by faculty and peers, the next stage is to enter into Schoology e-handout. Display virtual classroom and e-handout at Schoology in figure 3, figure 4 and figure 5.

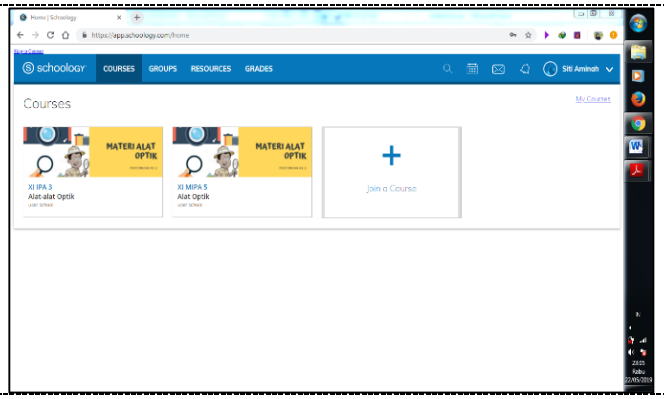


**Figure 3.** Virtual classroom schoology.

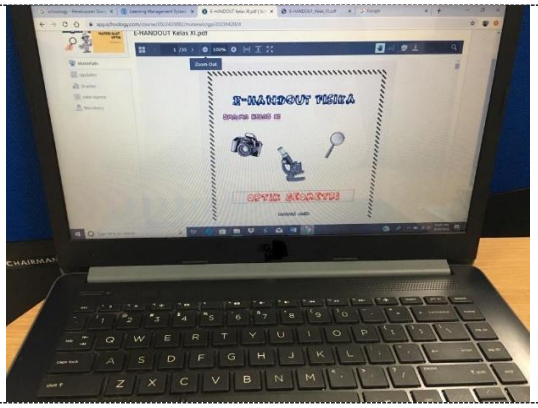


**Figure 4.** Display virtual classroom e-handout Schoology.

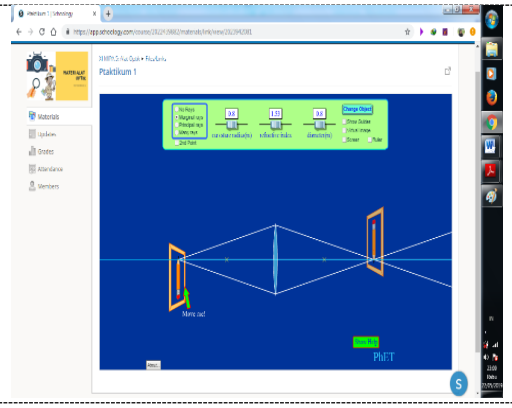


**Figure 5.** Display PhET simulation on Schoology.

Figure 3 shows a virtual class in schoology, figure 4 is an e-handout display in schoology and Figure 5 is a PhET simulation display in a student worksheet on schoology that is accessed using a laptop. The next step is to test the modeling class XI MIA 3 which is guided by students to access e-handouts in the virtual schoology class application. Here the teacher pays attention to the learning process from beginning to end. After learning how to access schoology and knowing the stages of using e-handouts, the teacher practices it in the implementation class, class XI MIA 5. With appropriate classrooms and the provision of weighted and interesting learning materials, students will be enthusiastic and responsible for each lesson in Schoology.

The results of the validation of the feasibility of PBL E-handout assisted with PhET simulations through the developed Schoology media are appropriate to be used as learning resources for students of class XI of SMAN 1 Sleman. The use of E-handouts is also able to give a positive value to student learning outcomes. The results of this study are supported by [9,10] regarding teaching materials for handouts, [17] regarding PhET simulations in physics learning both to be applied in learning because it is difficult to do in the laboratory and [21], [22] regarding e-learning through Schoology media.

## 4. Conclusion

The development of PBL E-handout is assisted by the Simulation of Optical Materials PhET - LUP Camera and Microscope Lenses is a learning resource that can be used as a source and medium for learning. This electronic handout has student worksheets that have been completed with PBL syntax. The student worksheet in the e-handout is linked to the PhET simulation link. Students can access e-handouts in virtual Schoology classes. Overall validation by experts, ranging from media experts, material experts and colleagues, it can be concluded that the development of PBL e-handouts assisted with PhET simulations is used without revision and is suitable for use in innovative physics learning in schools.

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