Development of e-handout assisted by PhET simulation with problem based learning (PBL) model about momentum conservation law and collision to train students' conceptual understanding

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Abstract. The research produce an e-handout assisted by PhET simulation with problem based learning (PBL) model about momentum conservation law and collision to train students' conceptual understanding. The e-handout was developed which use to train the conceptual understanding of students, which was previously conducted a feasibility test on e-handouts. The research uses the ADDIE development model. The subjects of the research were students of SMA N 1 Sleman class X MIA. The instrument used in data collection in the form of validation sheets by experts, students' questionnaire responses, and conceptual understanding test instrument. The data obtained and it analyzed quantitatively. The result showed that e-handout development was carried out in accordance with product development procedures, validation of expert show that e-handouts have very high criteria, the results of the questionnaire responses of students showed that the e-handout was appropriate to be used as a medium for learning physics with a good category, the result of understanding the concept have improved significantly. Based on the result above, the research shows that the development of e-handouts is feasible to be used as teaching material and it is known that students' understanding of concepts in learning physics can be improved.
Keywords: *e-handout, problem based learning (PBL), PheT, conceptual understanding*

1. Introduction

Physics learning activities should be oriented to students where students have a effort to learn by themselves directly through practical activities. In practical activities students will be better to understand the concepts of physics. So the physics learning can takes place can involve students. Therefore, the visualization of physical concepts with practical activities in explaining is inseparable from the curriculum which applies in the case the 2013 Curriculum.

The 21st Century learning implies that a teacher must use digital technology, communication facilities to access, manage, integrate, evaluate and create information which has a function in learning. The 4.0 era of revolution has brought change of the world in education from the incorporation of technology into learning and produce educational innovation for the future [1].

In this era, 21st century learning is learning which requires skill to be able to adapt to existing change. A set of skills must be possessed by students in this era which include critical thinking, science concept,

problem solving [2], [3], the ability to apply information technology, digital capabilities [4], innovation creativity, communication, collaboration and critical thinking [5], [6].

The 2013 curriculum is the answer of challenges faced by the nation in the future. Basic competencies need to be possessed by high school students are: (1) analyzing concepts, principles, and laws of physics, (2) using metacognition to explain natural phenomena and solving life problems, (3) modifying or designing simple projects by applying physics concepts [7].

The physics learning process requires students are not only to memorize theories and formulas, but also it emphasizes the formation of a process in knowledge and understanding of concept [8]. In this era, physics is considered difficult of many students, one factor is the lack of variation in media and method in learning [9]. Therefore, they need the right media and learning method to overcome them. There are developing teaching materials, and learning media by utilizing information and communication technology (ICT) in learning physics. The development of ICT enables the production of interactive multimedia which can be facilitate students in learning physics concept.

Interactive multimedia can be used is PhET. The use of PhET aims to link and visualize physical concepts in real terms and can be used directly of students to learn about material and understand concepts [10], [11]. Therefore, the use of PhET simulation is felt necessary by researchers to optimize understanding of learning material properly, as well as target learning outcomes can be achieved.

Based on the 2013 curriculum, using innovative learning model can be one solution to improve students' cognitive abilities. The model which used is problem based learning (PBL). PBL is able to train students in applying various concepts in physics. PBL focuses on learning activities in enhancing students' understanding of concept and learning outcomes [12], [13] as well as encouraging understanding of scientific knowledge [14]. The result of observation in physics learning class X in SMA N 1 Sleman shows that learning activities do not actively involve students and the optimal use of facilities provided such as LCD projectors.

The use of information and communication technology in learning is help students' improvement in understanding of concept. Thus, the students need a media or teaching material which support of learning. There is using e-handouts. Handout contains concise and concise material, and there are also equipped with evaluation questions that the e-handout is expected to facilitate students in understanding the material [15]. The e-handout combines PBL model and electronic media which equipped with student worksheet and PhET simulation. PhET simulation is used as the application of 21st century learning.

Therefore, the research presents the development e-handout assisted by PhET simulation with problem based learning (PBL) model about momentum conservation law and collision to train students' conceptual understanding. It expected to the e-handout which develop, (1) in accordance with the development procedures. (2) e-handout using PhET simulation with PBL model are in good category. (3) based on the questionnaire responses of students developed the e-handout is feasible to use. (4) there is a significant improvement in understanding of concept.

2. Research method

The research was conducted at SMA N 1 Sleman with the object of research was the class X MIA students even semester 2018/2019. The subjects of the research were determined by purposive sampling technique. Time activity of the research was carried out in April 2019 until May 2019.

The model which used of the research is the ADDIE model [16]. The ADDIE development model consists of five stages, there are: (1) analysis; (2) design; (3) development; (4) implementation, and (5) evaluation. The ADDIE model used in the research can be seen in figure 1.

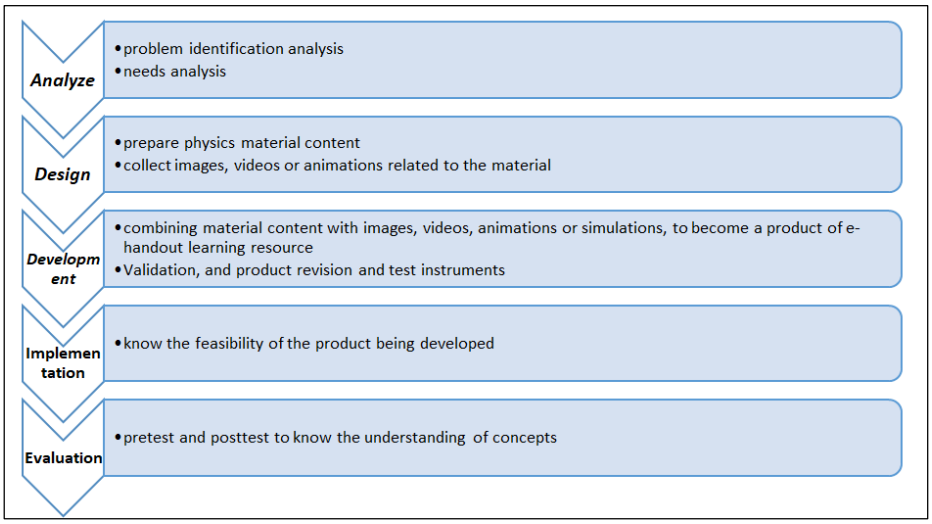


Figure 1. Steps for the ADDIE development model.

The field test was conducted during two meetings. The steps used in the study are to provide Pretest, treatment, Posttest. The research design can be seen in table 1.

Table 1. Pre-Experiment Disign

Pretest	Treatment	Posttest
O_1	X	O_2

O_1 = Pretest score; O_2 = Posttest score; X = learning by using e-handout with the simulation of PhET using PBL model; treatment effectiveness = $O_2 - O_1$

Data collection is done using test and non-test techniques. Test techniques are giving students Pretest and Posttest questions. Pretest questions are used to find out the initial understanding students which forms of questions contain multiple choice and 10 questions. The results of the Pretest score are used to analyze the level of understanding of students' initial concept. In Pretest, students are given treatment in form of a learning process using e-handout assisted by PhET simulation with PBL model. In the last of the lesson, a Posttest was conducted to measure students' understanding of the concept after the treatment, the test instrument is used that same with the Pretest. The non-test technique is carried out using data collection instrument in form of an expert validation sheet, which consists of material expert, media expert and student questionnaire responses. The e-handout validation data is analyzed using descriptive analysis using equation 1.

$$\text{Values Obtain (N)} = \frac{\text{Amount of scores obtained}}{\text{Maximum score number}} \times 100\% \quad (1)$$

Then the results of the analysis are converted to values with the criteria shown in table 2. Adapted from Mardapi.

Table 2. Assesment categories.

Respondent score	Categories
$X \geq \overline{X_i} + 1.0SBi$	Very high
$\overline{X_i} + 1.0SBi > X \geq \overline{X_i}$	High
$\overline{X_i} > X \geq \overline{X_i} - 1.0\ SBi$	Low
$X < \overline{X_i} - 1.0\ SBi$	Very low

In calculating, a quantitative score is obtained and changed to the qualitative category. Table 3 shows the conversion of quantitative scores into qualitative categories in the validation analysis of e-handouts by material expert.

Table 3. Convert quantitative scores to qualitative categories on e-handout validation by material experts.

Respondent score	Categories
$X \geq 20{,}7$	Very high
$X \geq 20{,}7$	High
$15{,}5 > X \geq 10{,}3$	Low
$X < 10{,}3$	Very low

Table 4 shows the conversion of quantitative scores into qualitative categories in the validation analysis of e-handouts by media experts.

Table 4. Convert quantitative scores to qualitative categories on e-handout validation by media experts.

Respondent score	Categories
$X \geq 14$	Very high
$14 > X \geq 10{,}5$	High
$10{,}5 > X \geq 7$	Low
$X < 7$	Very low

Measurement of the validity of e-handouts is done by using a questionnaire given to students. The results of the questionnaire analysis can be calculated using the formula as in equation 2.

$$\text{Values Obtain (N)} = \frac{\text{Amount of scores obtained}}{\text{Maximum score number}} \times 100\% \quad (2)$$

The percentage validity of e-handouts is determined based on the values which refer to the criteria as shown in table 5. Adapted from Arikunto.

Table 5. Validity criteria for e-handouts.

Respondent score	Categories
76 % - 100 %	Very good
56 % - 75 %	Good
40 % - 55 %	Enough
< 40 %	Not good

The results of the measurement of conceptual understanding analyzed using descriptive analysis to find he average score of the Pretest and Posttest. Then it compares to find out the improvement in understanding of the concept after the treatment. The use of e-handout assisted by PhET simulation with PBL models is said to be effective if there is a significant improvement of conceptual understanding scores.

3. Results and discussion

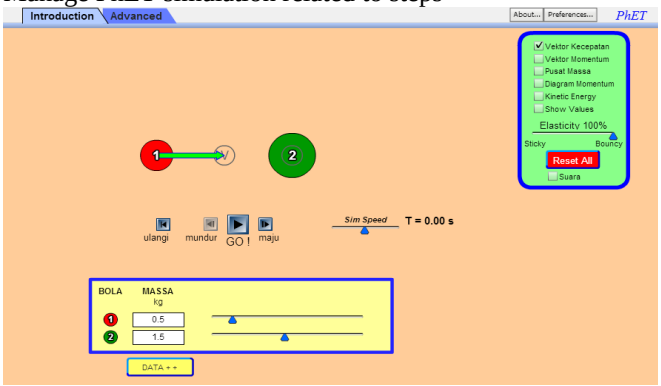
The product development of the research is an e-handout assisted by PhET simulation with PBL model equipped with student worksheet. In addition, the research also developed a validation instrument and the feasibility of e-handouts and measuring instrument for understanding students' concepts. The development phase begins with designing e-handouts, which followed by validation. Then, the validation results are revised according to needs.

3.1 Results of development

The result of the need analysis are done by collecting primary data in form of observations and interviews about the need of learning resources of students and teacher in learning physics. The problem is found in learning, where e-handout needs to be developed aided by PhET simulation with PBL model. The PhET simulation is used contain momentum conservation law.

The following is a student worksheet matrix with a PBL model assisted by the existing PhET simulation in the e-handout development.

Table 6. Student worksheet matric with PBL model which helped PhET in e-handout development.

Activity of LKPD based on PBL Phase	Interaction	Practice Understanding Concepts
Interrogate students of the problem	Give apperception and motivation Give questions related to the animation / video of law conversation in momentum and impact	Build base of the definition
Negotiation of students to learn	Create a hypothesis about law conversation in momentum and impact related of animation and video which given before Answer the questions of LKPD of *e-handout*	Oral explanation
Guide group investigations	Manage PhET simulation related to steps 	
Develop and preset work result of students	Write the result experiment activity	Connect discovery to the theory
Analyze and evaluate problem solving process	Analyze data from experiment	Connect discovery to the theory concept Present the experimental result

The ability to understand concept can be improved by developing physics learning devices with PBL models [17]. One of the tool developed of the research is e-handout are equipped with LKPD-assisted PhET simulation developed with PBL model.

3.2 Results of validation

Based on the result of the e-handout validation conducted by media expert and material expert which consists of 2 lecturers as validators. The result obtained adjusted to the criteria in table 3 and table 4. The result of the e-handout assessment by material and media expert in each aspect are shown in table 7 and table 8. Table 7 shows the highest score of the result of the e-handout validation in the aspect in material appropriate with core competent and standar competent and presentation supporters. Table 8

shows the highest score of the results of the e-handout validation in the aspects of language, physical appearance and presentation.

Table 7. Results of the e-handout validation assessment by material experts on each aspect.

Aspect	Score	Categories
Material appropriate with core competent and standar competent	38	Very high
Material feasibility	19	High
Material which up to date	19	High
Straightforward	12	Low
Communicative and interactive language	12	Low
Use of symbols and formulas	12	Low
Presenting technique	19	High
Presenting support	32	Very high
Presenting	12	Low
PhET simulation which helped of experimental activity	19	High

Table 8. Result of the e-handout validation assessment by media experts on each aspect.

Category	Score	Aspect	Category	Score	Aspect	Category
Clarity of sentences	19	Very high	Clarity of sentences	19	Very high	Clarity of sentences
Linguistic	47	Very high	Linguistic	47	Very high	Linguistic
Program	19	Very high	Program	19	Very high	Program

Overall results of the e-handout assessment are shown in table 9.

Table 9. Results of the e-handout validation assessment by experts.

	Score	Categories
Media expert	21	Very high
Material expert	31	Very high

Table 9 shows the e-handout is in very high category. It can be used in high school physics learning. E-handout has student worksheet can be seen in figure 2 and figure 3.

Figure 2. Introduction to the material and direction to student worksheet.

Figure 3. Experimental activities that lead to student worksheet with a PhET simulation.

While student worksheet activities related to PBL are shown in the figure 4 and figure 5.

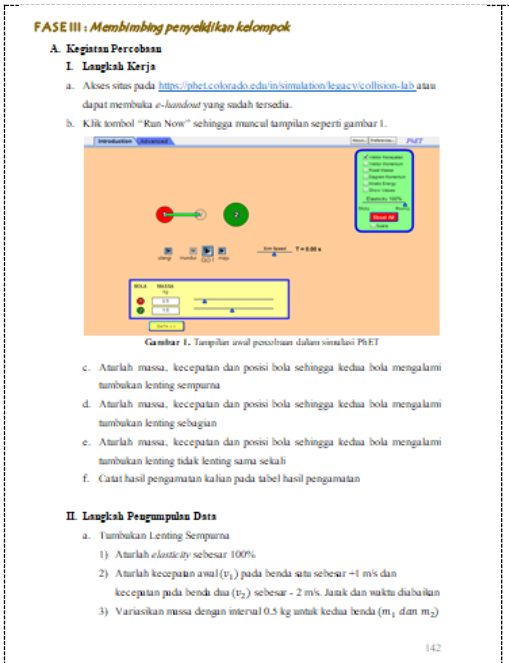


Figure 4. Guide group investigations.

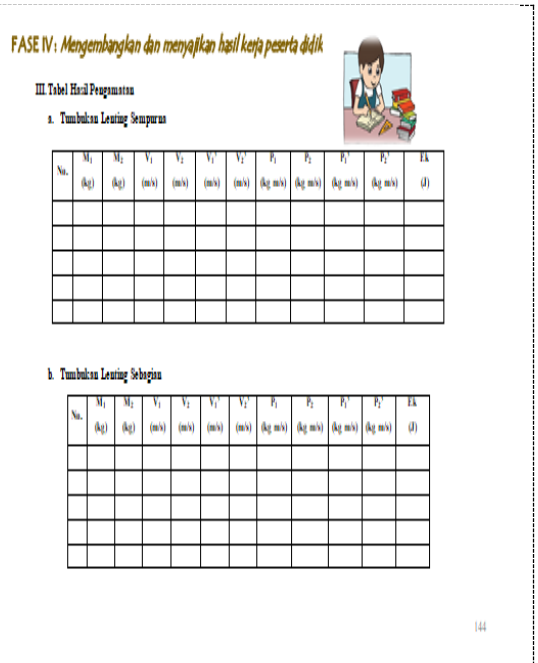


Figure 5. Develop and present the work or discussion of students.

The assessment of feasibility in e-handout result using the student response questionnaire is shown in table 10.

Table 10. Results of the feasibility assessment e-handout.

Score	Categories
77.6 %	Good

Table 10 shows that the developed e-handouts are feasible for use in physics learning in either category.

In addition to learning tools, data collection instruments are also validated beforehand by experts. The validated instrument is a concept understanding test instrument. From the validation, the results show that the developed test instrument is valid for use.

3.3 Results of products implementation

Measurement of students' understanding of concepts is done before and after learning. The result of the measurement in concept understanding obtained of an average score in each test as descriptive analysis material. The results of the analysis are shown in table 11.

Tabel 11. Score result of understanding concept.

	Students	Average
Pretest	30	52.00
Posttest	30	76.00

Table 11 shows that the average change in students' understanding of concepts related to Pretest and Posttest conducted was 52.00 and 76.00 respectively. Thus, based on the scores obtained, it can be seen that there are significant changes in the Pretest and Posttest average scores.

Changes in the Pretest and Posttest average scores indicate that there is an increase in learning outcomes after the use of e-handouts assisted by PhET simulations with PBL models in learning. This shows that PBL models can improve students' understanding of concepts [18], as well as by the use of animations / simulations to increase understanding of concepts [19]. So, it can be concluded that there is an increase in conceptual understanding before and after using the e-handout that was developed.

4. Conclusion

The conclusions obtained from the research are: (1) the development of e-handout assisted by PhET simulation with PBL model carried out in accordance with product development procedures. (2) the result of expert validation showed that e-handouts have very high criteria. (3) the result of the questionnaire responses of students showed that the e-handout was appropriate to be used as a medium for learning physics in high school with a good category. (4) the use of e-handout assisted by PhET simulation with PBL model can significantly improve the understanding of high school physics concept.

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