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The Development of the E-Student Worksheet Assisted with PhET Simulation on the Material of Momentum and Impulse for High School/Islamic High School Levels

Susi Febrianti[1*], **Sri Nengsih**[1], **Arusman**[1]

[1] Physics Education Study Program, UIN Ar-Raniry Banda Aceh, Indonesia
*Corresponding author: susifebrianti298@gmail.com

ABSTRACT

The limited facilities in the laboratory are an obstacle for students in carrying out practicums. The material on momentum and impulse is considered complicated by students, this is due to the limited use of printed books as the only teaching material in the physics learning process. Therefore, it is necessary to use additional teaching materials in the form of E-Student Worksheet to help students understand the concepts of momentum and impulse. This research has two main objectives, namely to design an E-Student Worksheet design assisted by PhET Simulation and to determine the feasibility of the e-worksheet. Making E-Student Worksheet with the help of PhET Simulation is used as an interactive learning animation simulation to deepen understanding and increase students' interest in physics. The E-Student Worksheet development process assisted by PhET Simulation follows the model developed by Alessi and Trollip, which consists of three stages: (1) Planning, (2) Design, and (3) Development. The result of this research is E-Student Worksheet assisted by PhET Simulation which focuses on momentum and impulse material. Determining the suitability of the product is carried out through validation by media experts and material experts, with the percentage of media expert validation reaching 94.37%, and material expert validation reaching 93.14%. Based on these results, it can be concluded that E-Student Worksheet is very suitable for teaching material in the learning process.

INTISARI

Permasalahan keterbatasan fasilitas di laboratorium menjadi kendala bagi peserta didik untuk melakukan praktikum. Materi momentum dan impuls dianggap rumit oleh peserta didik, hal ini disebabkan oleh keterbatasan penggunaan buku cetak sebagai satu-satunya bahan ajar dalam proses pembelajaran fisika. Oleh karena itu, diperlukan penggunaan bahan ajar tambahan berupa E-LKPD untuk membantu peserta didik memahami konsep momentum dan impuls. Penelitian ini memiliki dua tujuan utama, yaitu untuk merancang desain E-LKPD berbantuan *PhET Simulation* dan untuk mengetahui kelayakan E-LKPD tersebut. Pembuatan E-LKPD berbantuan *PhET Simulation* digunakan sebagai simulasi animasi pembelajaran yang bersifat interaktif, sehingga akan memperdalam pemahaman dan meningkatkan minat peserta didik

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* Corresponding author:
Susi Febrianti, Physics Education Study Program, UIN Ar-Raniry Banda Aceh, Indonesia
✉ susifebrianti298@gmail.com

terhadap ilmu fisika. Proses pengembangan E-LKPD berbantuan *PhET Simulation* mengikuti model yang telah dikembangkan oleh Alessi dan Trollip, yang terdiri dari tiga tahap: (1) Perencanaan (*Planning*), (2) Perancangan (*Design*), dan (3) Pengembangan (*Development*). Hasil dari penelitian ini adalah E-LKPD berbantuan *PhET Simulation* yang fokus pada materi momentum dan impuls. Mengetahui kelayakan produk dilakukan melalui validasi oleh ahli media dan ahli materi, dengan persentase validasi ahli media mencapai 94,37%, dan validasi ahli materi mencapai 93,14%. Berdasarkan hasil tersebut dapat disimpulkan bahwa E-LKPD ini extremely feasible digunakan sebagai bahan ajar dalam proses pembelajaran.

A. Introduction

The teaching style of an educator has a significant impact on the readiness and ability of students to absorb the material. The responsibility of an educator involves managing the classroom and enjoyably delivering lessons. Efforts are being made to ensure that the knowledge provided can be effectively applied in everyday life [1]. Interest in the learning process is a psychological factor that influences every individual during the learning process. When students have a high interest in learning, engagement in the learning process arises naturally from within themselves [2]. Learning media is important to implement in the classroom so that learning activities develop and have a positive impact on the quality of education [3]. The use of media such as videos and animations can provide a more enjoyable and engaging learning experience for students. The use of various media can support the learning process by presenting information in an interesting way that captures students' attention. Sometimes, computer simulations can also serve as a substitute for direct experiments in the laboratory. Conducting experiments is an important part of learning science [4].

The challenges due to the limitations of laboratory equipment pose a serious obstacle in conducting practical learning in schools. Thus, many teachers cannot carry out practical activities, and this can hinder the learning process of students in an optimal way. To address this issue, teachers can use virtual laboratories as an alternative to school laboratories. The author proposes the utilization of a site called PhET Simulation. PhET Simulation offers various laboratory simulations within the context of online learning.

Based on the necessity analysis and difficulties of the students on February 3, 2023, at Muhammadiyah 09 High School in Kualuh Hulu, Kualuh Hulu district, Labuhan Batu Utara Regency, North Sumatra Province. The questionnaire results indicated that physics learning in schools still relied solely on printed books without any practical work so the students could not understand the material explained by the teacher. Students also wanted to conduct practical work in the laboratory, but due to limited practical equipment at school, the researcher offered to carry out the practical work using PhET Simulation.

Several previous studies reveal that PhET simulation encourages students to be more enthusiastic in the learning process. Rizky Nafaida et al. found that the average score percentage of 85.91 among students indicates feelings of happiness and increased interest in the PhET-based learning process [5]. Siti Ita Masita et al. found that PhET simulation could enhance students' understanding of physics concepts [6].

Previous research found Student Worksheet was crucial in the learning process and suitable for improving mastery of the material. Melva Oktavia et al. found that teaching materials such as Student Worksheet and learning media were essential for the learning process in schools. One of them is the Student Worksheet based on PhET simulation [7]. Hantika and Supahar found the effectiveness of the REACT-based Student Worksheet assisted by PhET Simulation for improving the mastery of material and science process skills of eleventh-grade students [8].

Student Worksheets are usually in printed form. Along with the development of technology, many innovations in the presentation of Student Worksheet by adopting an electronic format are available, known as e-worksheet, to support learning activities. The developed e-worksheet would be packaged in the form of descriptive text, images, and videos. This e-worksheet is created in Microsoft Word, converted to PDF, and then transformed into an electronic book or FlipBook using the Flip PDF Corporation application.

This research has two main objectives: to design the e-worksheet assisted by PhET Simulation and to determine the feasibility of the e-worksheet. The creation of the e-worksheet assisted by PhET Simulation serves as an interactive learning animation simulation, which will deepen students' understanding and increase their interest in physics. The process of developing e-worksheet assisted by PhET Simulation follows the model developed by Alessi and Trollip, which consists of three stages: (1) Planning, (2) Design, and (3) Development.

B. Method

Research and development methods are defined as a research approach to produce specific products and examine the effectiveness or potential of those products [9]. Research and development serve to validate the accuracy and develop educational materials in the form of e-worksheets [10]. The applied development model in this research is the Alessi and Trollip model. The Alessi and Trollip Development Process consists of three important phases: Planning, Design, and Development [11].

The research location was at Muhammadiyah 09 Kualuh Hulu High School. The study was conducted in February 2023 by distributing questionnaires to students and teachers and conducting interviews with subject teachers. This research validated the sustainability of the developed products. This test involved three media experts, namely a lecturer in Electrical Engineering Education, and three subject matter experts, the lecturers in Physics Education from the Faculty of Tarbiyah and Teacher Training at UIN Ar-Raniry Banda Aceh.

The types of obtained data in this research consist of two types: qualitative data and quantitative data. The qualitative data is derived from initial observations, critiques, and suggestions from media experts and content experts. Several suggestions were made for product improvement during the revision stage. Quantitative data was collected through the completion of assessment questionnaires by validators, aimed at determining whether the product is suitable for trial and can be used as supplementary teaching material in the learning process. The research instrument used is a validation sheet by validators. The validation sheet is a collection of statements aimed at obtaining critiques, suggestions, and corrections regarding the developed product.

The researchers analyzed the data to determine the feasibility of the product developed by the validator using a Likert scale questionnaire. The response questionnaire for this feasibility assessment has 5 evaluation criteria, such as: "very feasible," "feasible," "sufficiently feasible," "less feasible," and "not feasible." Each has a different score that indicates the level of feasibility. The total assessment score can be calculated using the formula (1):

$$P = \frac{\sum X}{\sum X_i} \times 100\% \quad (1)$$

Remarks :

P = Percentage of each criterion

$\sum X$ = the obtained score of each aspect

$\sum X_i$ = the maximum score of each aspect

Table 1 shows the feasibility criteria of the obtained results.

Table 1. The Criteria of the Feasibility Percentages [12]

The Criteria of Feasibility Percentages	The Degree of Feasibility
81%-100%	Extremely Feasible
61%-80%	Feasible
41%-60%	Averagely Feasible
21%-40%	Less Feasible
<20%	Not Feasible

C. Result and Discussion

Result

The results of the development research conducted by the researchers produced a product in the form of an e-worksheet assisted by PhET Simulation. Researchers collected data from Muhammadiyah High School 09 Kualuh Hulu. The analysis of necessity and difficulties in developing teaching materials was conducted with students and teachers by interviewing the subject teachers. Meanwhile, the product trial was conducted by three expert lecturers in media and content. The e-worksheet assisted by PhET Simulation is accessible online or offline once the file is downloaded.

Before conducting the research, the researcher distributed questionnaires to students and teachers and also conducted interviews with subject teachers to understand the importance of providing additional teaching materials in the learning process. The results of the interview indicate that during physics lessons, students desire real practical work in the laboratory. However, due to the limitations of laboratory equipment, in this case, the researcher proposes conducting the practical work using PhET Simulation. This is also supported by the availability of facilities at school, such as underutilized computers that could be optimized for virtual practical applications. Meanwhile, the results of the questionnaire analyzing the difficulties with the material found that students were struggling to understand the concepts of momentum and impulse because they only studied from printed books without any practical exercises. Thus, they could not grasp the material explained by the teacher. On the other hand, momentum and impulse are concepts that exist in everyday life [13]. Therefore, students are required to be able to analyze and think logically about these concepts [14]. The results of the questionnaire also indicate that students need teaching materials in the form of e-worksheets. The following are the components included in the e-worksheet such as:

Here are the components of the e-worksheet:

a. Cover

The cover page displays text and images; the text includes the main title of the teaching material, the identity of the material developer, the identity of the institution, and the name of the supervising lecturer. The images include the PhET Colorado Edu logo, an animation of a car crash, and images of impulse and momentum. Figure 1 shows the cover page.

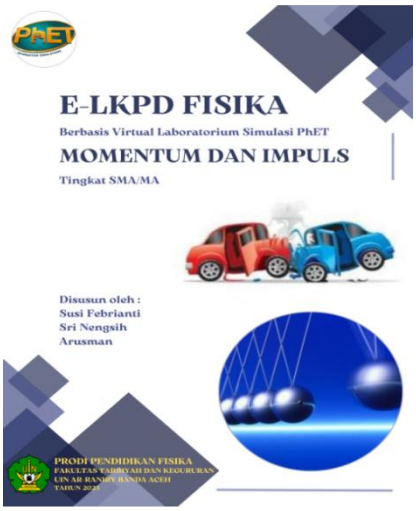


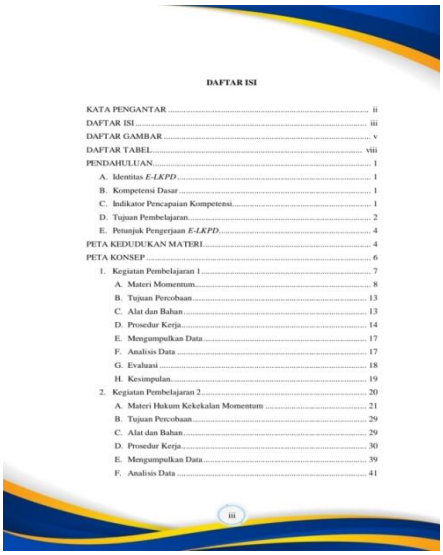
Figure 1. The Cover Page

b. The Preface Page

The display of the preface consists of the e-worksheet descriptions and the rear part of the preface has the author's expectation toward the developed e-worksheet.

c. The Content Page

The display of the content page consists of the materials of the e-worksheet, and the function to show the page sites of the e-worksheet parts. Figure 2 shows the content page content.



DAFTAR ISI

Figure 2. The Content List Page

d. The Figure List Page

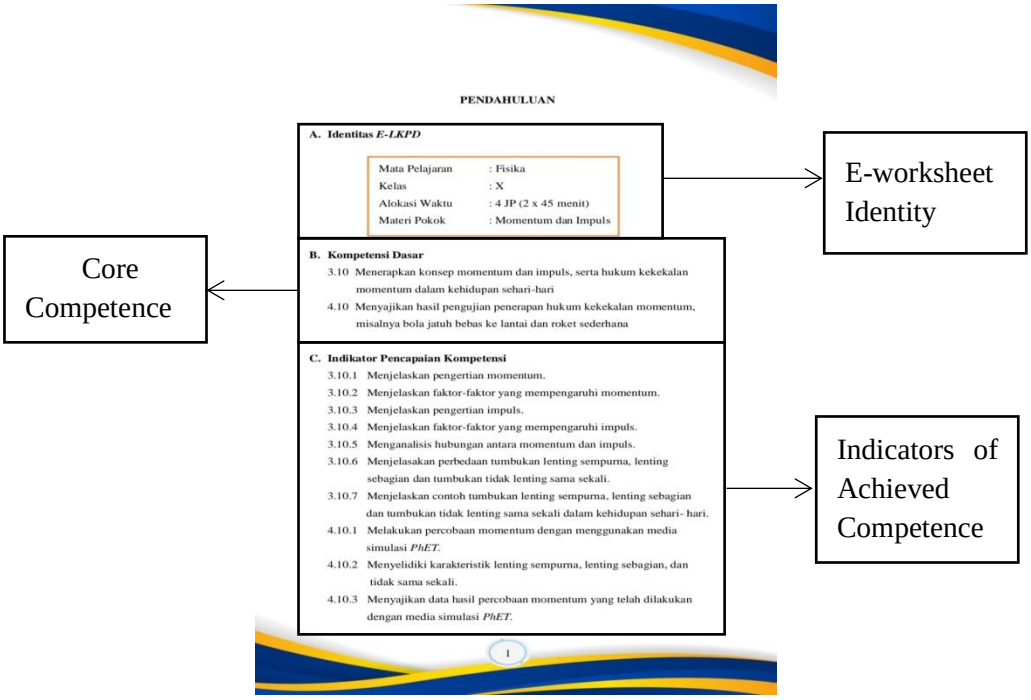
The figure list page consists of the figures of the e-worksheet to show the page sites of the figures in the e-worksheet.

e. The Table List Page

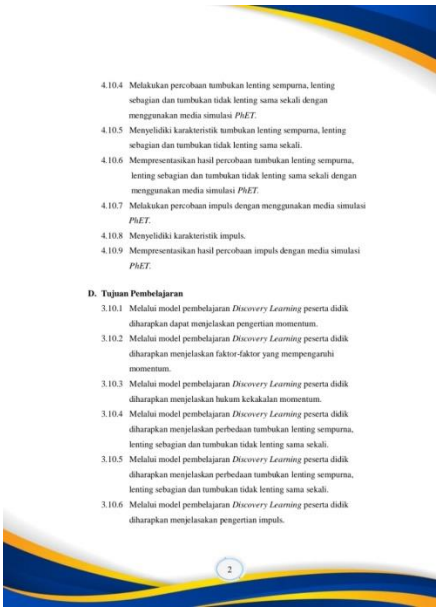
This page shows the parts of the tables in the e-worksheet, the function to show the page sites of the table parts.

f. The Introduction

This page consists of the e-worksheet identity, core competence, indicator of the achieved competence, learning objective, and guidance to use e-worksheet. The core competence was arranged based on the ministerial regulation of the Educational and Cultural Ministry number 37 in the year 2018. The elaborated core competence 3.10 and 4.10 include 17 indicators of achieved competence. Figure 3 shows the introduction page.



(a) E-worksheet identity, Core competence, and Indicators of Achieved Competence



(b) Learning Objectives

(c) The Guidance to Use e-Worksheet

Figure 3. The Introduction Page

g. The Mapping Page of the Materials

The mapping page about the materials consists of material grouping for the tenth, eleventh, and twelfth grades of SHS and ISHS. Figure 4 shows the mapping page of the materials.

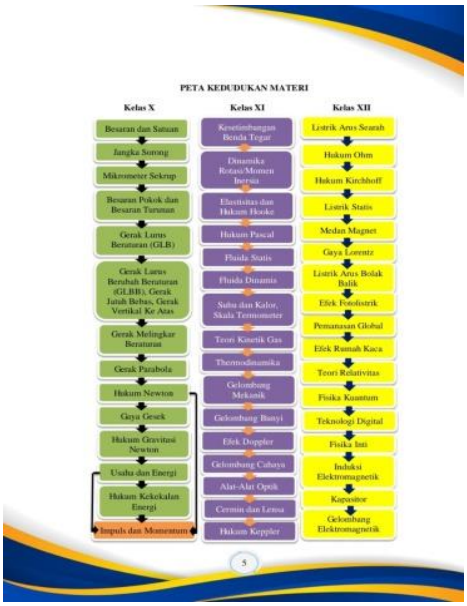


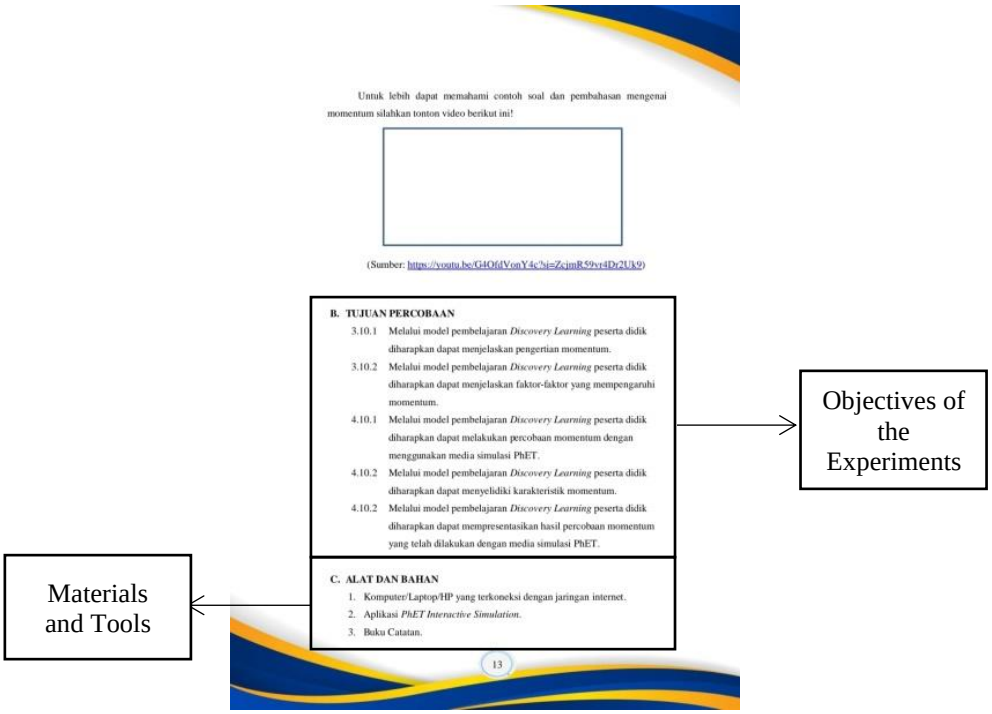
Figure 4. The Mapping Page of the Materials

h. The Conceptual Map Page

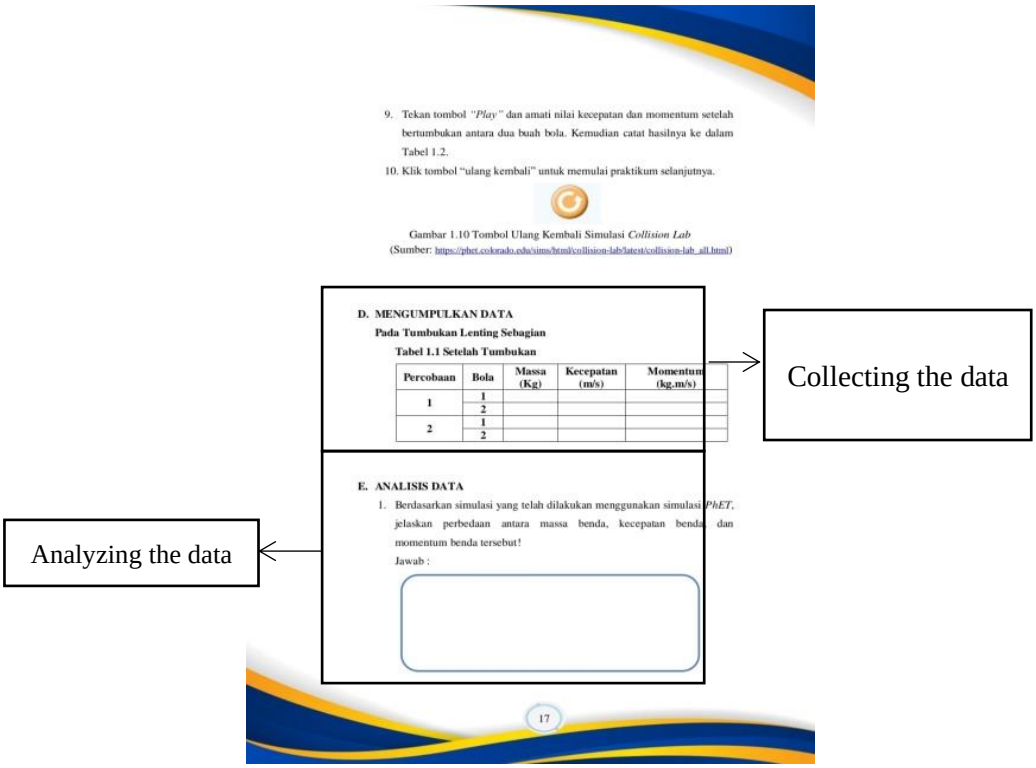
This page consists of the flowchart of the materials to describe the materials accurately.

i. The Learning Activity Page

This page shows the students' identities, learning materials, objectives of the experiments, materials, and tools, working procedures, data collections, data analyses, evaluations, and conclusions. Figure 5 shows the learning activity page.



(a) Objectives of experiment, materials, and tools



(b) Collecting and Analyzing the Data

Figure 5. The Learning Activity Page

j. The Bibliography Page & The Curriculum Vitae

This page shows the references of the authors during the learning activity and shows the authors' photographs and biographies.

The results of each stage of this procedure produce potential issues in data collection, product design, design validation, design revision, product testing, and product revision. Media and content experts first validated the researchers before conducting the trials. The experts validated the researchers using a questionnaire they had provided, after which the validators evaluated the aspects outlined in the questionnaire. The validation conducted by media experts and content experts yielded the following results:

Table 2. The Media Expert Validation Results

Indicators of Assessment	Feasibility Percentage	Feasibility Criteria
E-worksheet cover design	96.66%	Extremely feasible
Object Design of the Teaching Material	92.08%	Extremely feasible
The mean total of all scores Content	94.37%	Extremely feasible

Table 2. The Material Expert Validation Results

Indicators of Assessment	Feasibility Percentage	Feasibility Criteria
Material relevance with core competence	100%	Extremely feasible
Material accuracy	88.88%	Extremely feasible
Material update	96.66%	Extremely feasible
Displaying technique	88.88%	Extremely feasible
Supporting display	96.66%	Extremely feasible
Learning display	96.66%	Extremely feasible
Brief	91.11%	Extremely feasible
Communicative	93.33%	Extremely feasible
Dialogic and interactive	93.33%	Extremely feasible
Relevance with learners' development	86.66%	Extremely feasible
Relevance with grammar	88.88%	Extremely feasible
The mean total of all scores Content	93.14%	Extremely feasible

The tables shows media expert shares the highest validation results. It means that the developed product is extremely feasible for further use in trials, considering the design of the e-worksheet cover and the content design of the teaching materials. The average score from media assessment experts for the design of the e-worksheet cover and the content design of the teaching materials is 94.37%. The validation results from content experts yielded lower results compared to the validation results from media experts, considered extremely feasible by the three validators for the next trial.

Discussion

The learning materials developed are in the form of e-worksheets assisted by PhET Simulation, which can be accessed via the internet (online). This aims to utilize technology in an increasingly advanced era. Learning can be conducted both offline and online, requiring teachers to engage in innovative practices in education, so that the knowledge imparted is effectively conveyed.

Netti's research reveals the use of PhET Simulation during the learning process that requires the implementation of real laboratory experiments is very effective and

easy to use by educators and students [15]. This also supports researchers in using teaching materials accessed through the internet because they are relevant and advantageous according to their characteristics. The researchers chose PhET Simulation-assisted teaching materials to conduct experiments amidst the limitations of practical tools in schools.

This development was carried out through a literature review to understand the necessity of this research. A field study was conducted at Muhammadiyah 09 High School Kualuh Hulu to understand the learning conditions at the school. There are several differences in previous research. In the research by Oktavia [8] and Dewi Novita [2], the development of the Student Worksheet (LKPD) was based on Problem-Based Learning and Discovery Learning. Therefore, this research required a relatively long time due to the complex procedures to follow.

The results of the field study indicate that the school being researched requires teaching materials that enable students to learn actively and independently during the learning process. So far, no teachers have utilized e-worksheets supported by PhET Simulation as teaching materials in the learning process. Meisyaroh's research on the development of PhET Simulation-assisted e-worksheet to enhance learning independence and critical thinking [11]. This study concludes that the PhET Simulation-assisted e-worksheet is extremely feasible for teaching material in physics education.

D. Conclusion

This research concludes that the researchers successfully created teaching materials in the form of e-worksheets assisted by PhET Simulation on the topic of momentum and impulse. The validation results are extremely feasible for testing in schools. The advantage of the product (e-worksheet assisted by PhET Simulation) is that it is an online learning material that can be accessed using a mobile phone, laptop, computer, and so on. This learning material can be accessed anytime and anywhere, provided there is an internet connection. This e-worksheet is the latest variation in the physics learning process that utilizes PhET Simulation, complete with interactive images and videos so that students do not feel bored while studying the material taught by the teacher. The drawbacks of this product are that it requires a computer, phone, and laptop that are connected to the internet, and at certain times, the links contained in the e-worksheet cannot be used. Suggestions from researchers for future studies include testing the e-worksheet assisted by PhET Simulation on the topic of momentum and impulse for students so that the developed teaching materials can be utilized in the learning process at schools.

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