Volume 4 Issue 1, June 2024

ISSN 2798-1762 (Print)
ISSN 2798-1754 (Online)

Impulse

Journal of Research and Innovation in Physics Education

Published by
Pendidikan Fisika
UIN Sunan Kalijaga Yogyakarta

Impulse: Journal of Research and Innovation in Physics Education

Volume 4 Issue 1, June 2024

Published by:
Pendidikan Fisika
Fakultas Ilmu Tarbiyah dan Keguruan
UIN Sunan Kalijaga Yogyakarta
Indonesia

ISSN 2798-1762 (Print)
ISSN 2798-1754 (Online)

CONTENTS

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, Sri Nengsih, Arusman
UIN Ar-Raniry Banda Aceh

53–63

DOI: 10.14421/impulse.2024.41-01

IMPULSE: Journal of Research and Innovation in Physics Education
Volume 4, Issue 1, 1 – 11

© ISSN (p): 2798–1762; ISSN (e): 2798-1754
http://ejournal.uin-suka.ac.id/tarbiyah/impulse

Development of Renewable Energy Modules with Contextual Teaching Learning Helpful Augmented Reality (AR) Integrated Al-Qur'an Class X SMA/MA

M Karlina[1*], A N Chandra[1], M Imamora[1], H Idrus[1]

[1]Department of Physics, UIN Mahmud Yunus Batusangkar, Indonesia
*Corresponding author: karlinamella2020@gmail.com

ABSTRACT
This research was motivated by the limited teaching materials used by educators in the learning process. The only teaching materials available are textbooks and handouts, but there are no learning modules yet. The research was conducted on renewable energy material for class X SMA/MA. Augmented Reality (AR) is needed for renewable energy materials to be able to change images into three dimensions. Research conducted at Madrasah Aliyah strongly supports modules that integrate verses from the Koran. Therefore, it is necessary to develop a Renewable Energy module with Contextual Teaching Learning assisted by Augmented Reality (AR) integrated with the Koran. The type of development research used is the 4-D model (Define, Design, Development, Dissemination). However, the development of this AR-based integrated physics learning module for Al-Qur'an verses only uses three stages, namely Define, Design, and Development. The instrument used in this research is the validation sheet. The research results show that the module developed is valid and very practical for use by educators and students in learning.

INTISARI

Penelitian ini dilatarbelakangi karena terbatasnya bahan ajar yang digunakan pendidik dalam proses pembelajaran. Bahan ajar yang ada hanya buku paket dan handout, namun modul pembelajaran belum ada. Penelitian dilakukan pada materi energi terbarukan kelas X SMA/MA. Augmented Reality (AR) dibutuhkan pada materi energi terbarukan untuk dapat mengubah gambar menjadi tiga dimensi. Penelitian dilakukan di Madrasah Aliyah sangat mendukung modul yang terintegrasi ayat Al-Qur'an. Oleh karena itu, perlu adanya pengembangan modul Energi Terbarukan dengan Contextual Teaching Learning berbantuan Augmented Reality (AR) terintegrasi Al-Qur'an. Jenis Penelitian pengembangan yang dipakai yakni model 4-D (Define, Design, Development, Dissemination). Namun, pengembangan modul pembelajaran fisika terintegrasi ayat Al-Qur'an berbasis AR ini hanya menggunakan tiga tahapan saja yakni Define, Design, and Development. The instrument used in this research is the validation sheet. Hasil penelitian menunjukkan modul yang

ARTICLE HISTORY
Received: February 15, 2024
Accepted: July 01, 2024

KEYWORDS:
Module, Contextual Teaching Learning, Augmented Reality (AR), Renewable Energy

KATA KUNCI:
Modul, Contextual Teaching Learning, Augmented Reality (AR), Energi Terbarukan

* Corresponding author:

Mella Karlina, Department of Physics, UIN Mahmud Yunus Batusangkar, Indonesia
karlinamella2020@gmail.com

dikembangkan valid dan sangat praktis digunakan oleh pendidik dan peserta didik dalam pembelajaran.

A. Introduction

The Advances in science and technology, especially information technology, have a major influence on the construction and implementation of learning strategies. With these advances, educators can use various types of media according to learning needs and objectives. Apart from facilitating and maximizing the learning process, media can also make learning more interesting. Based on the results of interviews with educators and students at MAN 2 Tanah Datar, researchers found several problems in the learning process, especially physics. Students find physics material difficult because there are a lot of calculations and it seems monotonous. This is due to the lack of teaching materials used by educators in the learning process and educators often use the lecture method in delivering the material so that students are less interested and feel bored in following the lesson.

Teaching materials generally used in learning are textbooks and handouts. Apart from textbooks, the teaching materials available at the school also include handouts. However, the inadequate number of printed books available is not balanced with the number of students so that not all students have printed books. Students can only borrow printed books from the library to read in class while studying. There are also handouts, made by educators themselves, which contain a summary of the material and practice questions. However, handouts were not distributed to students. Therefore, learning activities become one-way centered on educators (teacher centered). In line with that, according to Daryanto [1] teaching materials that make it easier to achieve specific learning objectives are modules.

Modules are teaching materials designed in a comprehensive and structured manner, which contain learning experiences created to master specific learning objectives [1]. A module is a book designed with the intention that students can learn it individually even without a teacher [2]. The advantages of the module in general are that it can overcome time constraints, various methods can be used, students are more active in learning, this module does not only consist of material but also has practice questions.

Based on the independent curriculum, learning must be in accordance with the context of a contextual approach, one of which is the Contextual Teaching learning model. As explained by Amelia [3] this model allows learning to occur in contexts that are relevant to students' daily lives, creating meaningful and relevant learning experiences. The advantage of Contextual Teaching and Learning is that learning becomes more meaningful and real. This means that students are required to be able to grasp the relationship between learning experiences at school and real life. The use of this module is so that students can more easily understand material that is difficult to understand.

In previous research, several have conducted research regarding the development of teaching materials, one of which was teaching modules using AR and the results of this research showed that there was an increase in students' understanding of the material being taught and helped educators in delivering learning material easily. The swift progress of technology in today's revolutionary era, particularly its growing incorporation into educational settings, marks a substantial transformation in teaching and learning methodologies on a global scale [4]. Technology-based learning can ignite students' enthusiasm for learning, because it is facilitated by the inclusion of animated elements, graphical explanations, and a variety of colors, all of which enhance the learning experience and make it more immersive [5]. Based on Firdaus's research [6], learning modules based on Augmented Reality (AR) integrated with Al-Qur'an verses can increase students' motivation and interest in learning. Integration is a model of unification between scientific values with spiritual values and other things so as to have complete uncertainty and avoid separating them within a scientific discipline [7]. The creation of this integrated module for Al-Quran verses aims to assist in the learning process, so that the learning process can be made interesting because it has Islamic nuances, and can increase students' interest in learning.

Physics is a subject whose application uses learning modules to make it easier for educators to convey the subject matter. One of the materials that requires a module to apply is renewable energy material, because this material contains theories that are difficult to visualize, making students less interested and bored of learning. To make it easier for students to understand the concept of learning material, educators use the CTL method in teaching so that students can make direct connections between learning material at school and students' daily lives. CTL is a learning concept that helps teachers relate learning material to students' real-world situations and conditions, and encourages students to apply it in everyday life [8]. To attract students' attention in learning, it would be better if this renewable energy material was visualized in 3D.

The difference between 2D modules and 3D modules is in their appearance. In ordinary modules there are only 2D images which do not attract students' attention. To make the module more interesting, technology is needed to view the images in the 3D module. One way to display module images in 3D is by using AR technology. AR is a visual technology that can combine virtual objects into real form. This technology can be applied as an innovative learning medium by implementing it on smartphones [9]. In various fields including AR technology education has been applied. AR Learning Media can visualize abstract concepts for understanding and the structure of an object model, making AR an effective medium in accordance with the objectives of learning media. Science is one field that applies the development of AR technology. Three-dimensional (3D) objects can be displayed on Android Smartphones with the help of AR Technology.

The advantages of AR are that it is fun, can create 3D objects and animations as if they were in a real environment, and should be used as an alternative learning medium. The application used to create AR is the Assembler Edu application. Assembler Edu is an application that converts objects into 3D and AR. This application allows users to create interactive learning materials. The advantages of the Assembler Edu application are that it is easy to use, has an attractive appearance, provides the necessary materials and is virtual based. In this application, objects can be used to visualize learning material. In this application, users can work in creating learning materials. Not only can you design it yourself, this application also contains several materials that can be used directly by educators.

MAN 2 Tanah Datar is an Islamic school based on the Qur'an. MAN 2 Tanah Datar has the vision "a Ministry of Religion that is professional and reliable in building a pious, moderate, intelligent and superior society, to create an advanced Indonesia, one that is sovereign, independent and has a personality based on mutual cooperation." Islamic schools can integrate learning with verses from the Koran, but at MAN 2 Tanah Datar there are no teaching materials that integrate the Koran. By having material that integrates the Qur'an, it can strengthen the bond between the Physics module and the clear life stated in the Qur'an and strengthen religion. This is in line with research conducted by Chandra et al. [10], Integrating the Al-Qur'an in the development of science, especially physics, is very important for an educator to do. Therefore, now we see many people who are smart, but use any means to achieve their success. Therefore, integrating the Koran into learning is very important. Based on this background description, it is necessary to develop teaching materials in the form of a Renewable Energy Module with Contextual Teaching Learning Assisted by Augmented Reality (AR) Integrated with the Al-Qur'an for Class X SMA/MA."

B. Method

The research carried out used research and development (R&D) methods with the aim of developing a Renewable Energy Module with Contextual Teaching Learning help Augmented Reality (AR) Integrated Al-Qur'an. The development model used in this research is the model proposed by Thiagarajan in Sutarti & Irawan [11], namely the 4D model. The 4D model consists of 4 development stages, namely: definition (define), planning (design), development (develop), as well as the spread (disseminate). At the level of define Observations and interviews were carried out with educators, analyzing CP, TP and material, analyzing the learning media used and material obstacles that were difficult to understand. At stage design done product planning. At the level of development Validation of the module and practicality testing of the module is carried out. The instrument used in this research is the validation sheet. Data analysis techniques are obtained from quantitative data, data obtained quantitatively comes from validation instruments.This data analysis

technique is carried out quantitatively. This quantitatively processed data comes from several instruments, namely:

Validation Sheet

The validation sheet is based on data obtained from the validator, so the validation results can be searched using the equation:

$$P = \frac{\sum score\ per\ item}{maximum\ score}\ x\ 100\% \quad (1)$$

With validation categories in Table 1 [12]:

Table 1 Validation Categories

Interval	Category
0 – 20%	Invalid
21 – 40%	Not valid
41 – 60%	Fairly valid
61 – 80%	Valid
81 – 100%	Very valid

Practicality Sheet

This practicality sheet is filled in by educators and students to obtain information that will be used as a reference. After that, the existing information is collected and grouped, so that it can be calculated using the equation (1). As a result of the data obtained, each range is categorized as follows in Table 2 [12].

Table 2 Practicality Categories

Interval	Category
0 – 20%	Impractical
21 – 40%	Not practical
41 – 60%	Quite practical
61 – 80%	Practical
81 – 100%	Very practical

C. Result and Discussion

At the level of Define Observations and interviews have been carried out with educators and students. From these interviews, information was obtained that in the learning process educators use teaching materials such as textbooks and handout, there is no use of modules yet. The appearance of printed books is less attractive and the use of language that is difficult to understand, this becomes an obstacle for

students in understanding the learning material. Apart from that, the learning process is still centered on educators who still use the systemteacher centered, learning is still centered on educators.

At the level of Design A module design is carried out consisting of several stages referring to Sutarti & Irawan [11], namely: a) creating a Media Program Outline (GBPM) as seen in Table 1, b) creating flowchart or flow chart of the program to be created from opening to closing, c) create storyboard to explain parts the part that's inside flowchart which contains writing, images, audio as seen in Figure 1, d) collect the objects to be designed, all the necessary materials are collected first such as materials, 3D images created using the application Assemblr Edu, e) combine all materials into a developed module, f) finishing, At this stage, a review of the module is carried out by conducting trials before it is validated. Testing was carried out on the AR barcode whether it could run smoothly or not. An overview of the appearance of this product can be seen in Figure 2.

Table 3. Media Program Outline (GBPM)

No	Aspect	Description
1.	Title	Renewable Energy Module with Contextual Teaching Learning Helpful Augmented Reality (AR) Integrated Al-Qur'an Class X SMA/MA
2.	Education Units	High School (SMA)/Madrasah Aliyah (MA)
3.	Class/ Semester	X/2
4.	Subjects	Physics
5.	Learning materials	Renewable energy
6.	Learning objectives	a. Classify the basic forms of energy b. Identify forms of energy, their changes in everyday life c. Analyze the application of the Law of Conservation of Mechanical Energy to events that occur in everyday life d. Find the problem of energy availability in the environment around where you live e. Find potential energy sources in the environment around where you live f. Plan a design for making a simple energy producing prototype device as a solution to the problem of energy availability g. Make a simple energy producing prototype device, and h. Improve the design of a simple energy producing device or prototype that has been tested
7.	Media	Print and cellphone modules

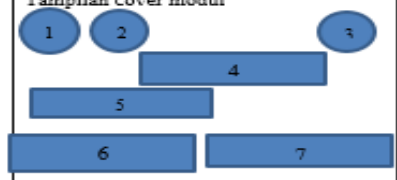
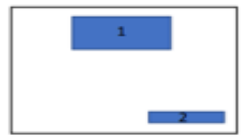
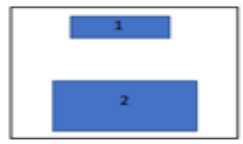
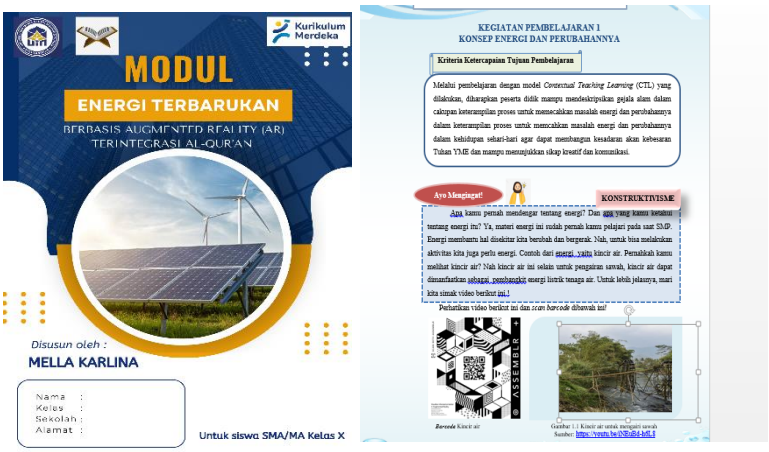
Rancangan	Visual	Audio	Keterangan
Tampilan cover modul 	1. Lambang kurikulum 2. Gambar integrasi Al-Qur'an 3. Lambang UIN Mahmud Yunus Batusangkar 4. Judul modul 5. Nama Penyusun 6. Identitas siswa 7. Untuk siswa SMA/MA kelas X		1. Lambang kurikulum merdeka 2. Gambar Al-Qur'an 3. Lambang UIN Mahmud Yunus Batusangkar 4. Judul modul :"Modul Energi Terbarukan Berbasis *Augmented Reality* (AR) Terintegrasi Al-Qur'an" 5. Nama Penyusun : Mella Karlina 6. Identitas siswa (nama, kelas, sekolah alamat) 7. Untuk siswa SMA/MA kelas X
Kata Pengantar 	1. Kata Pengantar 2. Nama Penulis		1. Uraian kata pengantar terdapat kalimat rasa syukur, judul modul yang dibuat 2. Nama Penulis : Mella Karlina
Daftar Isi 	1. Judul "Daftar Isi" 2. Judul sub bab materi		Pada daftar isi berisi susunan apa saja yang terdapat di dalam modul mulai dari kata pengantar, judul sub bab materi hingga daftar Pustaka. Pada daftar isi ini kita bisa melihat halaman-halaman yang ada di dalam nya

Figure 1. Example Storyboard

As seen in Figure 1, the material in the Renewable Energy module shows that the module has distinctive design characteristics cover module with a Renewable Energy image like a pinwheel as seen in Figure 1.a. Apart from that, it's about designcover Added an image of the Al-Qur'an which is a characteristic that this module is integrated with the Al-Qur'an. This module uses CTL syntax. This module is equipped with content Augmented Reality (AR) as seen in Figure 2. which is unique to this module in that the AR display is made into a barcode that can be scan and can display 3-dimensional images.



a) b)

Figure 1. Module Product

At the Development stage (Development) validation of the modules developed is carried out. The validation process is carried out by material expert validators, media expert validators, and interpretation expert validators using validation sheet instruments. The aspects discussed in the material validation instrument are appropriateness of content, appropriateness of presentation, quality of language. Aspects discussed in the instrument. media expert validation, namely graphic aspects and language aspects. Meanwhile, the aspects assessed in interpretation validation are the quality of the content, appropriateness of presentation, quality of language. Each aspect consists of several indicators that support the creation of modules that are valid and suitable for use in learning activities. At this stage the validator provides input and suggestions to support the creation of an interesting module that can be used as a reference in learning. Some of the suggestions given by the validator are: a) correct writing errors, b) improve the background, cover and color combination to make it more attractive, c) improve the image size and formula formulation. Product validation results in the form of a Renewable Energy Module with Contextual Teaching Learning Assisted by AR Integrated Al-Qur'an Class X SMA/MA by material experts is shown in Table 4.

Table 4. Results of product validation by material experts

No	Aspects	Validator				Sum	Max	(%)	Category
		1	2	3	4				
1.	Eligibility content	47	48	51	51	197	224	87,94	Very valid
2.	Feasibility presentation	19	17	19	20	75	80	93,75	Very valid
3.	Quality Language	23	19	19	22	83	96	86,45	Very valid
	Average					355	400	88,75	Very valid

Based on Table 4, it can be concluded that the material validation results obtained a final result of 88.75% with a very valid category. Details of the material validation results can be seen in Appendix 7. Based on the results of this validation, it is concluded that the material in the Module is contained in accordance with the Learning Outcomes.

Product validation results in the form of a Renewable Energy Module with Contextual Teaching Learning Helpful Augmented Reality (AR) Integrated Al-Qur'an based on media experts is described in Table 5.

Table 5 Media Expert Validation Results

No	Aspects	Validator				Sum	Max	(%)	Category
		1	2	3	4				
1.	Graphics	60	55	63	57	235	272	86,39	Very valid
2.	Language	10	9	9	10	38	48	79,16	Valid
	Average					273	320	85,31	Very valid

Based on Table 5, it can be seen that the graphic aspect obtained 86.39% in the very valid category and the language aspect obtained 79.16% in the valid category so that an average of 85.31% was obtained in the very valid category. Based on the results of the media validation of this module, it can be concluded that the module can be used by students.

Tabel 6 Interpretation Expert Validation Results

No	Aspects	Validator		Sum	Max	(%)	Category
		1	2				
1.	Content quality	11	15	26	32	81,25	Very valid
2.	Feasibility of presentation	8	7	15	16	93,75	Very valid
3.	Language Quality	18	23	41	48	85,41	Very valid
	Average			82	96	85,41	Very valid

Based on Table 6, it shows that the content quality aspect obtained 81.25% in the very valid category and the presentation feasibility aspect obtained 93.75% in the very valid category, the language quality aspect obtained 85.41% in the very valid category so that an average of 85 was obtained 41% with a very valid category. Based on the results of the expert validation of this module, it can be concluded that the integration of the Al-Qur'an contained in the module can be used. The results of AR-based module development research carried out by Ilhamsyah et al. [13] also showed good results. Himawan & Ariswan [14] stated that using modules as standalone instructional materials offers the advantage of enabling students to assess their comprehension of learning content and gauge the extent of their skill absorption. To ensure a positive learning experience, the utilization of technology should align with a student-centered approach, placing the learner at the forefront of the educational process [15].

D. Conclusion

Based on the results of the research that has been carried out, it can be concluded that the Renewable Energy Module with Contextual Teaching Learning Helpful Augmented Reality (AR) Integrated Al-Qur'an was declared very valid with a percentage based on material experts of 88.75%, media 85.31% and interpretation 85.41%. So overall the validation of this module has a percentage of 86.49% with a very valid category. Thus, it can be concluded that the module developed is very valid and can be continued to the practicality stage.

Acknowledgements

Thank you to Physics Education students in 2020 and those who have contributed to the preparation of this article. Hopefully the data provided and contributions from related parties can be useful as they should be.

References

[1] Daryanto, *Menyusun Modul Bahan Ajar untuk Persiapan Guru dalam Mengajar*. Yogyakarta: Gava Media, 2013.

[2] R. D. Agustin, "Pengembangan Modul Pembelajaran Himpunan dengan Pendekatan Kontekstual untuk Kelas VII SMP," *JPM J. Pendidik. Mat.*, vol. 5, no. 1, p. 1, 2019, doi: 10.33474/jpm.v5i1.2624.

[3] O. Amelia, P. D. Sundari, F. Mufit, and W. S. Dewi, "Analisis Kebutuhan Pengembangan E-Modul dengan Pendekatan Contextual Teaching and Learning untuk Meningkatkan Pemahaman Konsep pada Materi Energi Terbarukan," *J. Ilm. Profesi Pendidik.*, vol. 9, no. 1, pp. 34–39, 2024, doi: 10.29303/jipp.v9i1.1849.

[4] W. A. N. Mukramah, M. Jannah, and M. A. Wahid, "E-Modul Termodinamika Berbasis Flipbook Maker," *J. Phi J. Pendidik. Fis. dan Fis. Terap.*, vol. 5, no. 2, pp. 53–59, 2019, doi: 10.22373/p-jpft.v1i3.7752.

[5] M. Ardiansyah, “Pemanfaatan Aplikasi KAHOOT! Sebagai Media Pembelajaran Matematika Kreatif,” *Jumlahku J. Mat. Ilm.*, vol. 6, no. 2, pp. 145–155, 2020, doi: 10.33222/jumlahku.v6i2.1136.
[6] E. Y. Firdaus, “Pengembangan Modul Pembelajaran Fisika Terintegrasi Ayat-Ayat Al-Qur’an Berbasis Augmented Reality (AR) pada Materi Fluida Kelas XI SMA/MA,” UIN Mahmud Yunus Batusangkar, 2023.
[7] M. Herman, “Integrasi dan Interkoneksi Ayat-Ayat Al-Qur’an dan Hadist dengan Ikatan Kimia,” *J. Educ. Dev. Inst.*, vol. 9, no. 2, pp. 317–327, 2021, doi: 10.37081/ed.v9i2.2537.
[8] M. Muslich, *KTSP: pembelajaran berbasis kompetensi dan kontekstual, panduan bagi guru, kepala sekolah, dan pengawas sekolah*. Bumi Aksara, 2007.
[9] R. Rachmawati, R. Wijayanti, and A. P. Anugraini, “Pengembangan eksplorasi MAR (Matematika Augmented Reality) dengan penguatan karakter pada materi bangun ruang sekolah dasar,” *Delta-Pi J. Mat. dan Pendidik. Mat.*, vol. 9, no. 2, 2020.
[10] A. N. Chandra, S. Haryati, and V. Haris, “Desain LKPD Fisika Berorientasi Al-Qur’an dengan Strategi Inkuiri Terbimbing terhadap Pencapaian Kompetensi Peserta Didik SMA/MA,” *Sainstek J. Sains dan Teknol.*, vol. 12, no. 1, p. 5, 2020, doi: 10.31958/js.v12i1.2198.
[11] T. Sutarti and E. Irawan, *Kiat sukses meraih hibah penelitian pengembangan*. Deepublish, 2017.
[12] R. Akdon, *Rumus dan Data dalam Aplikasi Statistika*. Bandung: Alfabeta, 2011.
[13] B. Y. Ilhamsyah, S. Sudarti, and S. Bektiarso, “Pengembangan Modul Fisika Berbasis Augmented Reality Materi Rangkaian Arus Searah untuk Siswa SMA,” *J. Pembelajaran Fis.*, vol. 11, no. 3, pp. 98–105, 2022, doi: 10.19184/jpf.v11i3.33689.
[14] N. A. Himawan and Ariswan, “Physics Learning E-Module Integrated with Practicing Pancasila Values on Momentum and Impulse: Is it Effective to Improve Students" Critical Thinking Skill and Hard Work Character?,” *J. Ilmu Pendidik. Fis.*, vol. 8, no. 1, pp. 30–41, 2023, doi: 10.26737/jipf.v8i1.3128.
[15] A. Oke and F. A. P. Fernandes, “Innovations in Teaching and Learning: Exploring the Perceptions of the Education Sector on the 4th Industrial Revolution (4IR),” *J. Open Innov. Technol. Mark. Complex.*, vol. 6, no. 2, 2020, doi: 10.3390/JOITMC6020031.

DOI: 10.14421/impulse.2024.41-02

IMPULSE: Journal of Research and Innovation in Physics Education
Volume 4, Issue 1, 12 – 21

© ISSN (p): 2798–1762; ISSN (e): 2798-1754
http://ejournal.uin-suka.ac.id/tarbiyah/impulse

The Influence of Discovery Learning Model Assisted by Multimedia Module on Students' Critical Thinking Skill

Zul Hidayatullah[1*], Theofilus Gratiamus Gusemanto[2]

[1] Department of Science Education, Faculty of Mathematics and Natural Sciences, Universitas Hamzanwadi, Indonesia
[2] SMAS St. Ignasius Loyola Labuan Bajo, Indonesia
*Corresponding author: zulhidayatullah5@gmail.com

ABSTRACT

Proficiency in critical thinking is a crucial attribute that students must possess to effectively navigate the advancements in science and technology in the contemporary era of the fourth industrial revolution. Nevertheless, children's critical thinking abilities remain relatively deficient, and receive minimal instruction. Multimedia modules reinforce a discovery learning approach, providing an alternate method for developing critical thinking abilities. This research aims to determine the influence of the multimedia-assisted discovery learning paradigm on the development of students' critical thinking abilities. The research used a quasi-experimental approach, specifically a pretest-posttest control group design. Purposive sampling served as the sampling approach, ensuring that the students in the two classes under comparison shared the same initial competencies. We divided the 68 students in the research sample into two classes: the experimental class and the control class. We assess students' critical thinking abilities by administering an essay examination that evaluates their performance on critical thinking benchmarks. The data analysis for this research employs the independent t-test and the N-gain test. The study reveals that the experimental class outperforms the control class in terms of students' critical thinking abilities. The t-test's statistical significance, with a p-value of 0.000 or less than 0.05, confirms that the multimedia module-assisted discovery learning model has a significant impact on students' critical thinking abilities about momentum and impulse materials. The N-gain analysis of pretest and posttest results for students in the experimental class indicates a moderate rise in the five critical thinking indicators. We can conduct further studies to adapt this learning strategy to different topics. However, it is crucial to recognize that the instructor must invest time and creativity in preparing this multimedia module.

INTISARI

Keterampilan berpikir kritis merupakan keterampilan penting yang harus dimiliki peserta didik dalam menghadapi perkembangan ilmu pengetahuan dan teknologi di era modern 4.0. Namun faktanya kemampuan berpikir kritis siswa masih tergolong rendah dan jarang dilatih. Salah satu alternatif untuk melatih kemampuan berpikir kritis adalah dengan penggunaan model Discovery Learning berbantuan modul multimedia. Penelitian ini bertujuan untuk

ARTICLE HISTORY
Received: May 5, 2024
Accepted: July 01, 2024

KEYWORDS:
Critical Thinking, Discovery Learning, Multimedia Module, Physics

KATA KUNCI:
Berpikir Kritis, Fisika, Model Pembelajaran Discovery, Modul Multimedia

* Corresponding author:
Zul Hidayatullah, Department of Science Education, Faculty of Mathematics and Natural Sciences, Universitas Hamzanwadi, Indonesia
✉ zulhidayatullah5@gmail.com ✆+62 813-3924-2571

mengetahui pengaruh model Discovery Learning berbantuan modul multimedia terhadap kemampuan berpikir kritis siswa. Jenis penelitian ini adalah eksperimen semu dengan desain kelompok kontrol pretest-posttest. Metode pengambilan sampel yang digunakan adalah purposive sampling dengan tujuan agar siswa pada kedua kelas yang dibandingkan mempunyai kemampuan awal yang sama. Sampel penelitian berjumlah 68 siswa yang dibagi menjadi dua kelas yaitu kelas eksperimen dan kelas kontrol. Kemampuan berpikir kritis siswa diukur menggunakan tes uraian yang didasarkan pada indikator berpikir kritis. Analisis data pada penelitian ini menggunakan uji t independen dan uji N-gain. Hasil analisis menunjukkan bahwa kemampuan berpikir kritis siswa pada kelas eksperimen lebih baik dibandingkan pada kelas kontrol. Hal ini terlihat dari hasil signifikansi uji t yang menunjukkan angka 0,000 atau lebih kecil dari 0,05, sehingga dapat disimpulkan bahwa terdapat pengaruh model Discovery Learning berbantuan modul multimedia terhadap kemampuan berpikir kritis siswa. pada materi momentum dan impuls. Secara lebih rinci terlihat kelima indikator berpikir kritis mengalami peningkatan pada kategori sedang berdasarkan analisis N-gain pada skor pretest dan posttest siswa kelas eksperimen. Penelitian selanjutnya dapat menerapkan pembelajaran seperti ini dengan materi yang berbeda, namun perlu diperhatikan bahwa penyusunan modul multimedia ini memerlukan waktu dan kreativitas guru.

A. Introduction

Science learning, especially physics in the 21st century, emphasizes high-level thinking skills. These high-level thinking skills help students have logical, critical, and systematic thinking that can solve every problem. High-level thinking skills in 21st-century learning include critical thinking, creativity, innovation, problem-solving and collaboration, and making decisions [1][2]. Critical thinking skills are a crucial aspect of higher-level thinking that pupils must possess [3]. This is because, in the 21st century, students need to possess strong information-filtering skills to false information. Additionally, they need to develop their critical thinking skills to effectively address any challenges. Critical thinking skills refer to students' ability to engage in logical reasoning and delve into the underlying aspects of a situation, including the identification of causes and effects.

Critical thinking is a cognitive process that involves the application of knowledge and skills to solve problems, make decisions, analyze assumptions, and conduct investigations or research using gathered data and information to generate desired information or conclusions [4]. Critical thinking skills are very necessary in the modern era as the goal of education [5]. Critical thinking skills are different from merely criticizing without a solution. This skill encourages students to consider and look for many alternative solutions based on existing facts. Therefore, learning at schools should develop critical thinking, innovation, creativity, and technological skills [6]. Critical thinking correlates with student academic achievement. Critical thinking encourages students' cognitive processes to highly think achieve excellent learning outcomes and become better [7]. However, students' critical thinking skills are still relatively low because of the transferring knowledge pattern without

considering students' thinking skills. Critical thinking skills are rarely trained [8] as observed in the unidirectional learning process. Tests and questions given to students frequently focus solely on low cognitive thinking, with an emphasis on rote memory.

Learning science or physics, in particular, entails several complex concepts that require strong reasoning and critical thinking skills for comprehension. Thus, it is imperative to cultivate critical thinking abilities in pupils from a young age to gradually enhance their critical thinking capabilities. There are multiple methods for cultivating critical thinking skills, such as administering assessments that assess critical thinking indicators, using engaging educational resources to enhance students' abstract conceptual reasoning skills, implementing diverse instructional models to prevent student monotony, and so on. The use of instructional media is critical, as numerous scientific subjects prove difficult to comprehend solely through verbal explanations, indicating the necessity of illustrative examples [9]. Multimedia is considered a very useful application of ICT in the learning process. Many complex and abstract concepts can be visualized with multimedia [10]. In this context, the use of educational media in scientific or physics education is critically important. Educational media refers to any tool or resource utilized to enhance the learning process, ensuring the effective and efficient delivery of educational content.

Currently, there is a wide range of learning media options, including multimedia modules, e-modules, virtual reality, augmented reality, simulations, virtual laboratories, smartphone-based media, and others. The multimedia module is a viable alternative for integrating into the educational curriculum. Multimedia is an educational approach that employs technology to stimulate student engagement and transform monotonous learning routines into enjoyable experiences [11]. Interactive multimedia is learning media that is structured in such a way as to combine text, audio, graphics, animation, and video in delivering teaching material that allows students to actively interact with each other [12]. Multimedia influences students' high-level thinking skills such as problem-solving, evaluation, hypothesis formulation and conclusion-making, and self-reflection. Learning with multimedia has a positive impact on students because learning is student-centered [13]. Interactive multimedia has increased learning outcomes, interaction, and critical thinking skills. However, there was still a lack of literature on learning multimedia to help students develop their thinking engagement [14]. The use of multimedia in teaching especially in developing countries builds students' intellectual capacity and knowledge that will help them compete favorably with their peers in every part of the world [15].

The multimedia module cannot run by itself. Multimedia modules must also be combined with suitable learning models so that learning delivery is effective. Using a learning model with the help of multimedia modules can make students understand concepts better and at the same time can train their thinking skills, especially critical thinking skills. One model that is suitable to be combined with a multimedia module

is discovery learning. Discovery learning requires students to actively discover concepts or prove their hypotheses through the process of discovery or experimentation independently [16][17]. The discovery learning model aims to increase active student involvement in obtaining information, reducing dependence on teachers so that learning becomes active and creative. This model also trains students to explore and utilize information sources other than teachers, so that students will be motivated in the learning process [18][19][20].

The multimedia module exposes students to a variety of media-based learning materials, including videos, audio, simulations, and virtual laboratories. This facilitates the process of discovering and acquiring knowledge through the use of discovery learning methods. Students may engage in exploratory tasks by examining the multimedia module's simulation or virtual laboratory. Even if students do not participate in actual discovery activities in the environment, they can observe and practice in the multimedia module's simulations or virtual labs. This enhances efficiency and indirectly fosters the development of pupils' critical thinking abilities. Furthermore, an additional benefit is the inclusion of a critical thinking assessment within the multimedia module, allowing students to promptly evaluate their comprehension and proficiency after completing the module. This research seeks to investigate the impact of utilizing the discovery learning model, with the assistance of a multimedia module, on the development of critical thinking skills.

B. Method

This quasi-experiment determines that the independent variable does not have an exclusive influence on the creation of the dependent variable. The research examines the impact of the discovery learning model, supported by multimedia modules, on critical thinking skills. The discovery learning model is the independent variable, while critical thinking ability is the dependent variable. This research used a pretest-posttest control group design. The applied sampling technique was purposive sampling to intentionally select students with similar initial skills. The study involved a total of 68 students, with 34 in the control class and 34 in the experimental class. The researchers subjected the experimental group to multimedia-assisted discovery learning, while the control group received no treatment and followed standard learning methods. Table 1 elucidates the study design employed.

Table 1. Research Design

Class Type	Pretest	Treatment	Posttest
Control	O_1	X_1	P_1
Experiment	O_2	X_2	P_2

O_1 represents the initial assessment score for the control class, while O_2 represents the initial assessment score for the experimental class. X_2 refers to the experimental class's learning using discovery learning with the assistance of a multimedia module, while X_1 represents conventional learning. P_1 represents the control class's final assessment score, and P_2 represents the experimental class's final assessment score.

The researchers conducted this investigation at SMAK St. Francis Xaverius Ruteng, located in East Nusa Tenggara in multiple stages, such as a pretest, three face-to-face learning sessions, and a final test as the concluding stage. The data collecting method was a critical thinking assessment consisting of five test items. The data analysis was an independent t-test to examine the impact of the treatment on the experimental group in comparison to the control group. Then, the researchers used an N-Gain assessment to measure the specific impact of the intervention with a multimedia module to facilitate discovery learning, on the enhancement of students' critical thinking skills. This assessment determined the improvement in each critical thinking indicator. Table 2 displays the N-Gain criteria utilized [21].

Table 2. N-Gain Score Interpretation

Interval Score N-Gain	Category
$0.70 \leq g \leq 1.00$	High
$0.30 \leq g < 0.70$	Medium
$0.00 \leq g < 0.30$	Low

C. Result and Discussion

The goal of this study is to investigate the impact of using the discovery learning approach with multimedia modules on the development of student's critical thinking skills. The early activities involved administering a pretest to assess the basic skills of students in the two courses selected for the study. Then, the researchers subjected the students to the two groups. The students in the experimental class acquired knowledge through the method of discovery learning with the assistance of multimedia modules. Students in the control group received instruction through traditional methods. The learning procedure consisted of three meetings, followed by a posttest to assess the critical thinking skills of the students in both groups. The administered critical thinking assessment comprised five descriptive questions based on the critical thinking indicators. Then, the researchers used SPSS 25 to examine the outcomes of the critical thinking assessment in the posttest. Table 3 presents the results.

Table 3. Comparison of Average Scores

Group Statistics			
Type Class	**N**	**Mean**	**Std. Deviation**
Experiment	34	81.992	7.579
Control	34	70.317	9.675

Table 3 clearly demonstrates that the experimental group has a higher mean score than students in the control class. The experimental group, with the implementation of multimedia, has a mean score of approximately 82. Conversely, the control class achieves an approximate mean score of 70. Then, the researchers conducted an independent t-test analysis to examine the difference in critical thinking skills between students in the experimental class and those in the control class, as indicated in Table 4.

Table 4. Independent t-Test Result

	Levene's Test		**Independent t Tes**	
Category	**F**	**Sig.**	**Sig. (2-tailed)**	**df**
Homogeneous	0.963	0.330	0.000	66

Table 4 shows the significance (2-tailed) value is 0.00 lower than 0.05, indicating the significant influence of multimedia-assisted discovery learning on students' critical thinking skills in the context of momentum and impulse material. Discovery learning enabled pupils to actively seek solutions to their issues, thereby enhancing their cognitive abilities. Discovery learning involves more than simply providing students with materials, akin to spoon-feeding a baby. However, this learning approach emphasizes students actively pursuing the truth of their beliefs through scientific methods, such as conducting experiments or making observations using virtual laboratories or simulations. This type of learning process gradually cultivates students' critical thinking abilities as they directly engage in it and actively seek to refine their own notions. Research demonstrates that the use of multimedia in discovery-based learning improves student learning outcomes. Utilizing multimedia enhances students' skills to visualize and comprehend information, thereby facilitating their acquisition of knowledge [22]. The use of multimedia-assisted discovery learning models helps the learning process in the classroom. Learning becomes two-way and more interesting [23]. To see the effect of multimedia-assisted discovery learning, see Table 5 below.

Table 5. N-Gain of Critical Thinking among Experimental Class Students

Critical Thinking Indicator	Score N-Gain	Category
Identify	0.41	Medium
Analysis	0.57	Medium
Problem-Solving	0.42	Medium
Inference	0.69	Medium
Evaluation	0.33	Medium

Table 5 demonstrates the increase in each critical thinking indicator within the medium group, indicating the positive effects of the applied learning on the student's critical thinking skills in the subject of impulse-momentum. Various factors, such as the recent introduction of new learning models and media, contributed to the limited progress in students' critical thinking. Students were receiving their initial training in critical thinking skills. Previously, the learning process consisted solely of information transmission. Furthermore, utilizing multimedia modules in conjunction with the discovery learning paradigm could serve as an additional approach to improving students' critical thinking abilities. The discovery learning model has the advantage of encouraging students' engagement and retention of topics through active participation in conversations or activities with their peers. As a result, the use of superior learning models and learning materials directly correlated with a more substantial improvement in students' critical thinking abilities [24]. Other research concludes that the use of discovery learning can increase students' learning motivation so that their critical thinking skills also increase [25]. The use of media-assisted discovery learning can train students' cognitive skills to find and solve problems and can train students to learn independently [26]. Students enjoy learning when using the multimedia module because there are interesting simulations and animations and it can explain concepts they don't understand [27].

D. Conclusion

The data analysis and discussion outcomes suggest that the discovery learning paradigm, enhanced by multimedia modules, positively influences students' critical thinking abilities. Utilizing multimedia modules to facilitate exploration learning is more efficacious than traditional classroom instruction. Students in classrooms that utilize multimedia modules for discovery learning demonstrate enhanced critical thinking skills, surpassing their critical thinking skills in traditional classes. Specifically, the study demonstrates that students' critical thinking skills improve after engaging in discovery learning with the assistance of a multimedia module. On average, the improvement falls within the medium range. Furthermore, it is evident that students display greater enthusiasm for learning when exposed to multimedia modules because there are numerous captivating simulations. Nevertheless, it is

important to acknowledge that utilizing this multimedia module necessitates a significant amount of time for preparation and a comprehensive understanding of technology.

References

[1] M. S. Zohro, E. W. Winarni, and I. Koto, "Pengaruh Model Discovery Learning Berbantuan Multimedia Interaktif terhadap Kemampuan Berpikir Tingkat Tinggi pada Materi Pubertas Kelas VI SD," *J. Kapedas Kaji. Pendidik. Dasar*, vol. 3, no. 1, pp. 58–64, 2024.

[2] I. Sakti, A. Defianti, and N. Nirwana, "Implementasi Modul Ipa Berbasis Etnosains Masyarakat Bengkulu Materi Pengukuran Melalui Discovery Learning Untuk Meningkatkan Kemampuan Berpikir Kritis Mahasiswa," *J. Kumparan Fis.*, vol. 3, no. 3, pp. 232–238, 2020, doi: 10.33369/jkf.3.3.232-238.

[3] F. Fadlina, W. Artika*, K. Khairil, C. Nurmaliah, and A. Abdullah, "Penerapan Model Discovery Learning Berbasis STEM pada Materi Sistem Gerak Untuk Meningkatkan Keterampilan Berpikir Kritis," *J. Pendidik. Sains Indones.*, vol. 9, no. 1, pp. 99–107, 2021, doi: 10.24815/jpsi.v9i1.18591.

[4] A. A. Afiesta, M. Syam, and R. Qadar, "Pengaruh Model Discovery Learning Terhadap Kemampuan Berpikir Kritis Siswa SMA Negeri 9 Samarinda Materi Suhu dan Kalor," *J. Literasi Pendidik. Fis.*, vol. 3, no. 2, pp. 84–94, 2022.

[5] M. N. Majid, H. R. Achmadi, and N. Suprapto, "Studi Literatur Pemanfaatan Interactive Multimedia Related To Real Life Untuk Meningkatkan Keterampilan Berpikir Kritis Peserta Didik," *IPF Inov. Pendidik. Fis.*, vol. 9, no. 3, pp. 382–393, 2020, doi: 10.26740/ipf.v9n3.p382-393.

[6] P. Hendrajanti and S. Rochmiyati, "Peningkatan Keterampilan Berpikir Kritis dengan Discovery Learning Berbantuan Virtual Chemistry Laboratory," *J. Pendidik. dan Pembelajaran Sains Indones.*, vol. 6, no. 1, pp. 30–38, 2023.

[7] Y. D. Wicaksana, S. Widoretno, and S. Dwiastuti, "The use of critical thinking aspects on the module to enhance students' academic achievement," *Int. J. Instr.*, vol. 13, no. 2, pp. 303–314, 2020, doi: 10.29333/iji.2020.13221a.

[8] Rumiyati, "Optimalisasi Keterampilan Berpikir Kritis dan Hasil Belajar Melalui Implementasi Model Discovery Learning," *Acad. J. Inov. Ris. Akad.*, vol. 1, no. 1, pp. 1–10, 2021.

[9] N. A. Novitasari and A. M. Laili, "Pengaruh Model Discovery Learning Berbantuan Media Powerpoint Terhadap Kemampuan Berpikir Kritis IPA Siswa Kelas VIII," *LENSA (Lentera Sains) J. Pendidik. IPA*, vol. 13, no. 1, pp. 30–38, 2023, doi: 10.24929/lensa.v13i1.257.

[10] C. Ferreira, M. Baptista, and A. Arroio, "Teachers' pedagogical strategies for integrating multimedia tools in science teaching," *J. Balt. Sci. Educ.*, vol. 12, no. 4, pp. 509–524, 2013, doi: 10.33225/jbse/13.12.509.

[11] I. G. D. Buana, M. Putra, and I. G. S. Abadi, "Dampak Penggunaan Model Discovery Learning Berbantuan Multimedia Interaktif terhadap Kompetensi Pengetahuan PPKn Siswa Kelas IV Sekolah Dasar," *Indones. J. Instr.*, vol. 3, no. 2, pp. 54–63, 2022, doi: 10.23887/iji.v3i2.44508.

[12] O. Alpindo, "Validitas Handout Fisika Berbentuk Multimedia Interaktif dalam Model Discovery Learning untuk Meningkatkan Critical Thinking Skill Peserta Didik Kelas X SMA," *J. Edu Res.*, vol. 1, no. 2, pp. 1–10, 2020.
[13] U. Hasanah, I. M. Astra, and M. S. Sumantri, "Exploring the Need for Using Science Learning Multimedia to Improve Critical Thinking Elementary School Students: Teacher Perception," *Int. J. Instr.*, vol. 16, no. 1, pp. 417–440, 2023, doi: 10.29333/iji.2023.16123a.
[14] M. Rogti, "The Effect of Mobile-based Interactive Multimedia on Thinking Engagement and Cooperation," *Int. J. Instr.*, vol. 17, no. 1, pp. 673–696, 2024, doi: 10.29333/iji.2024.17135a.
[15] C. U. Ugwuoke *et al.*, "Effects of Multimedia Application on Students' Academic Achievement in Agricultural Science," *J. Balt. Sci. Educ.*, vol. 22, no. 6, pp. 1074–1088, 2023, doi: 10.33225/jbse/23.22.1074.
[16] M. Astika, Hikmawati, Sutrio, and Gunawan, "Pengembangan Perangkat Pembelajaran Model Discovery Learning untuk Meningkatkan Kemampuan Berpikir Kritis Fisika Peserta Didik," *J. Penelit. dan Pembelajaran Fis. Indones.*, vol. 3, no. 1, pp. 1–5, 2021.
[17] L. Septiaahmad, I. Sakti, and I. Setiawan, "Pengembangan Lembar Kerja Peserta Didik (LKPD) Fisika Berbasis Etnosains Menggunakan Model Discovery Learning Untuk Meningkatkan Keterampilan Berpikir Kritis Siswa Sma," *J. Kumparan Fis.*, vol. 3, no. 2, pp. 121–130, 2020, doi: 10.33369/jkf.3.2.121-130.
[18] S. Laeni, Zulkarnaen, and S. Efwinda, "Pengaruh Model Discovery Learning terhadap Kemampuan Berpikir Kritis Siswa SMA Negeri 13 Samarinda Materi Impuls dan Momentum," *J. Literasi Pendidik. Fis.*, vol. 3, no. 2, pp. 105–115, 2022.
[19] L. U. A. Nababan, M. A. Zulmi, M. J. Sihombing, and S. P. R. Harahap, "Meta Analisis Pengaruh Model Discovery Learning pada Mata Pelajaran Fisika terhadap Berpikir Kritis Siswa," *J. Inov. Pendidik. Sains dan Terap.*, vol. 2, no. 1, pp. 1–8, 2023.
[20] R. Surya, "Pengaruh Model Discovery Learning Berbantuan Multimedia Terhadap Keterampilan Proses Sains , Berpikir Tingkat Tinggi Dan Keterampilan Bertanya Pada Materi Sistem Pernapasan Di SMA Negeri 5 Langsa," *J. Biolokus*, vol. 3, no. 1, pp. 234–244, 2020.
[21] Z. Hidayatullah, M. Makhrus, and I. W. Gunada, "Pengaruh Pendekatan Konflik Kognitif Terhadap Hasil Belajar Gelombang Mekanik Peserta Didik MAN 2 Mataram," *J. Ilm. Profesi Pendidik.*, vol. 3, no. 2, pp. 171–175, 2018, doi: 10.29303/jipp.v3i2.27.
[22] R. Ihwono, A. Mariono, and U. Dewi, "Multimedia Web Learning Berbasis Model Pembelajaran Discovery Learning Untuk Meningkatkan Kemandirian Belajar Siswa Sma," *J. Educ. Dev.*, vol. 11, no. 2, pp. 413–419, 2023, doi: 10.37081/ed.v11i2.4566.
[23] T. S. Maria and Y. U. Lede, "Meningkatkan Keterampilan Bernalar Kritis Siswa SMP Pangudi Luhur Wedi Kelas 8B Menggunakan Model DIscovery Learning Berbantuan Multimedia," in *SEMNASPA: Prosiding Seminar Nasional Pendidikan Dan Agama*, 2023, pp. 1441–1446. doi: https://doi.org/10.55606/semnaspa.v4i2. 1378.

[24] A. N. Djepy, A. R. Tolangara, and T. D. Nur, "Pengaruh Penerapan Model Pembelajaran Discovery Learning Berbantuan Video Pembelajaran Terhadap Kemampuan Berpikir Kritis Dan Pemahaman Konsep Ipa Siswa Smp Negeri 44 Halmahera Barat," *J. Bioedukasi*, vol. 5, no. 2, pp. 124–133, 2022, doi: 10.33387/bioedu.v5i2.5403.
[25] Sholikhan, T. N. Amul, and N. Ain, "Memberdayakan Motivasi Belajar dan Keterampilan Berpikir Kritis Siswa Melalui Penerapan Model Pembelajaran Discovery pada Materi Getaran dan Gelombang," *J. Ris. Pendidik. dan Pengajaran*, vol. 2, no. 2, pp. 259–274, 2023.
[26] Nurfadillah, W. Cahyana, and D. P. Putra, "Penerapan Model DIscovery Learning Berbantuan Media Flipbooks dalam Pembelajaran Fisika untuk Melatih Keterampilan Metakognisi Siswa SMAN 10 Gowa," *J. Pendidik. MIPA*, vol. 12, no. 1, pp. 29–34, 2022, doi: https://doi.org/10.37630/jpm.v12i1.534 Penerapan.
[27] P. Nyirahabimana, E. Minani, M. Nduwingoma, and I. Kemeza, "Students' Perceptions of Multimedia Usage in Teaching and Learning Quantum Physics: Post-Assessment," *J. Balt. Sci. Educ.*, vol. 22, no. 1, pp. 37–56, 2023, doi: 10.33225/jbse/23.22.37.

DOI: 10.14421/impulse.2024.41-03

IMPULSE: Journal of Research and Innovation in Physics Education
Volume 4, Issue 1, 22 – 30

© ISSN (p): 2798–1762; ISSN (e): 2798-1754
http://ejournal.uin-suka.ac.id/tarbiyah/impulse

The Development of the Two-Tier Diagnostic Test Instrument with Google Form to Measure Student Misconceptions on Energy and Energy Forms

Ika Thalia Pratiwi[1], **Viyanti**[1*], **Dimas Permadi**[1]

[1] Department of Physics Education, Universitas Lampung, Indonesia
*Corresponding author: viyanti.1980@fkip.unila.ac.id

ABSTRACT

This study develops a two-tier diagnostic test instrument with Google Forms- to measure student misconceptions about energy and energy forms. The development research used the 4-D model with 4 stages: (1) define; (2) design; (3) develop; and (4) disseminate. The researchers validated the product to evaluate the construct, material, and language aspects. Expert validation results declared the two-tier diagnostic test instrument very valid at 87.7%. The researchers tested the two-tier diagnostic test instrument with Google form to measure student misconceptions on 30 students and then analyzed using the Rasch model with the assistance of Ministep 5.6.2 software. Based on the results of the Rasch analysis, 20 valid items were obtained. The questions on the two-tier diagnostic test instrument to measure student misconceptions were reliable, with a Cronbach alpha value of 0.66, categorized as adequate. The final product of the developed instrument met the standards of instrument validity and reliability.

INTISARI

Penelitian ini bertujuan untuk mengembangkan instrumen tes diagnostik two tier berbasis google form untuk mengukur miskonsepsi siswa pada materi energi dan bentuk-bentuk energi. Penelitian pengembangan menggunakan model 4-D dengan 4 tahapan yakni: (1) define; (2) design; (3) develop; (4) disseminate. Validasi produk untuk menilai aspek konstruk, materi, dan bahasa. Berdasarkan hasil validasi ahli instrumen tes diagnostik two tier dinyatakan sangat valid sebesar 87,7%. Instrumen tes diagnostik two tier berbasis google form untuk mengukur miskonsepsi siswa diujicobakan kepada 30 siswa dan selanjutnya dianalisis menggunakan model Rasch dengan berbantuan software Ministep 5.6.2. Berdasarkan hasil analisis rasch diperoleh sebanyak 20 butir soal yang valid. Soal-soal pada instrumen tes diagnostik two tier untuk mengukur miskonsepsi siswa dinyatakan reliabel dengan nilai alpha Cronbach sebesar 0,66 pada kategori cukup. Produk akhir dari instrumen yang telah dikembangkan telah memenuhi standar kelayakan instrumen yaitu valid dan reliabel.

ARTICLE HISTORY
Received: March 27, 2024
Accepted: July 01, 2024

KEYWORDS:
Assessment instrument, energy, google form. misconception

KATA KUNCI:
Energi, google form, instrumen tes, miskonsepsi

* Corresponding author:
Viyanti, Department of Physics Education, Universitas Lampung, Indonesia
✉ viyanti.1980@fkip.unila.ac.id

A. Introduction

Physics is the study of natural theories and concepts with human-interpreted explanations. Learning concepts, using them to solve physics questions, and doing science exercises are all crucial parts of studying physics [1]. Students find it challenging to understand physics principles because most students cannot connect between the learned materials and real-world applications. As a result, pupils make conceptual mistakes and come up with substitute ideas that lead to misunderstandings.

Misconceptions refer to discrepancies between the understanding of physics and the scientist's perception of the world. One of the challenges associated with studying physics is the presence of misconceptions, unnoticed by students [2]. The general procedures to identify the type of misconceptions are important to prevent misunderstandings such as identifying the cause, and choosing the best course of action [3]. A diagnostic test is one tool for dispelling myths. As a result, the creation of diagnostic exams that may gauge students' misconceptions is crucial to the assessment procedure and identifying misconceptions. The importance of this instrument development is crucial for SMAN 1 Kotabumi, which lacks a diagnostic test tool in terms of energy materials and forms of energy.

A diagnostic test identifies the pupils' areas of material understanding difficulty in a specific field of study. There are two types of diagnostic tests: cognitive and non-cognitive [4]. Diagnostic tests provide a comprehensive picture of students' cognitive preparation for learning, whereas non-cognitive diagnostics seek to ascertain students' psychological and social well-being as well as their learning preferences, personalities, and interests.

Education frequently uses technology, particularly for learning assessment and media [5]. Assessments examine the extent of changes in student learning outcomes and provide feedback to improve the learning process. The implementation procedure for assessments in the form of tests continues to rely on paper and stationery to support the assessment [5]. However, the high cost of money to duplicate questions and the prolonged time to prepare the answer sheets make the paper test ineffective. On the other hand, the implementation of the Internet for evaluation is excellent and useful such as with Google Forms. The Google Form is one tool available on the Google website for quizzing students or quickly and easily gathering information.

The capacity to do or create anything is known as energy [6]. Energy is necessary for all life. Humans use energy to drive motorcycles, cars, airplanes, and other vehicles in their daily lives since power can occur in these situations. Fitri & Oktavianty [7] and Fujiyati [8] revealed misconceptions about the correlation between effort and energy materials. Table 1 shows this matter.

Table 1. Misconceptions of Work and Energy

Literacy	Definition
Enterprises	Correlation between effort, force, and displacement
Kinetic Energy	Correlation between an object's position and kinetic energy
Potential Energy	Correlation between potential energy and mechanical energy
Law of Mechanical Energy Conservation	Objects have different amounts of energy

B. Method

This research and development created a diagnostic test instrument, consisting of questions with five answer choices. The first tier of the test measures students' misconceptions about energy and its forms. The second tier includes five choices of reasons that correspond to the first-tier answers. The researchers collected the data for this research using a Google Form. This research adopted Thiagarajan's 1974 4-D model, comprising four distinct stages: 1) Define the process, including the necessity analysis in terms of learners and learning objective; 2) Design the process, after the creation of diagnostic test in the form of a two-tier test on various energy materials and energy types; 3) Developing process, validating the materials by experts, revising, promoting limited trial run, and end-product revising; 4) Disseminating process, distributing products.

The data collecting instruments in this research included a questionnaire for teacher necessity analysis and a sheet for expert validity testing. The data collection strategies were obtaining data on validity and reliability test results. Three validators, specifically two physics education lecturers and one physics subject instructor, conducted the validation process. The researchers examined the data using a Likert scale score consisting of four levels: 1, 2, 3, and 4.

$$P = \frac{Total\ score\ obtained}{Sum\ of\ the\ highest\ scores} \times 100\% \qquad (1)$$

Description:
P = feasibility percentage

Table 2. Result Criteria Percentage of Feasibility

Percentage	Result Criteria
25% - 43.75%	Invalid
43.76% - 62.50%	Fairly Valid
62.51% - 81.25%	Valid
81.26 % - 100%	Very valid

The empirical validity test used the Rasch model with Ministep 5.6.2 software. This Rasch model could determine the interaction between respondents, items, and criteria for checking the suitability of items. Table 3 shows the item fit criteria.

Table 3. Item Fit Criteria

Percentage	Criteria
25% – 43.75%	Invalid
43.76% – 62.50%	Fairly Valid
62.51% – 81.25%	Valid
81.26 % – 100%	Very valid

Cronbach Alpha formula is useful to determine the reliability of the Rasch model. The researchers used the categories of reliability by the values of Cronbach Alpha. Table 4 shows the criteria.

Table 4. Item Reliability and Person Reliability Criteria

Value	Criteria
>0.94	Special
0.91 – 0.94	Very good
0.81 – 0.90	Good
0.67 – 0.80	Simply
>0.67	Weak

C. Result and Discussion

This research developed a two-tier diagnostic test instrument with Google Forms to measure student misconceptions about energy materials and evaluate the validity and reliability of various energy sources. The instrument product test was divided into two stages: the defining stage, including both theoretical and empirical investigations. The researchers conducted an empirical study at SMAN 1 Kotabumi to analyze the necessity of certain factors by distributing a questionnaire to three teachers at the school. The questionnaire comprised three analyzed aspects: the learning process, the online platform, and instrument development requirements. The preliminary study yielded field data that substantiated the research. Based on the questionnaire, the mean score of the development was 0.64, indicating the necessity of developing a diagnostic test instrument. Potential and present issues in the domain, specifically the failure of teachers to assess students' comprehension levels and devise efficient learning techniques, became the necessities of the development. The educators did not use internet tools for conducting evaluations. Teachers encountered challenges when using the two-tier diagnostic test instrument with Google Forms to assess student misconceptions.

The second step was designing stage. The researchers determined the instrument's structure in the design step by creating a two-tier diagnostic test instrument based on the learning objectives. The researchers designed the diagnostic

exam questions in a two-tier format, considering cognitive capacities derived from Bloom's taxonomy and concepts associated with energy and its various manifestations. The researchers divided the diagnostic exam questions into two tiers. The first tier consisted of questions with five answer choices, while the second tier with five corresponding options to the given answers in the first tier. Additionally, the test instrument provided rubrics, scoring criteria, and recommendations for answering questions. Therefore, the researchers divided the text into three sections: the first section consisted of the cover, preface, table of contents, and rationale. The content section consisted of a grid, instructions, instrument form, instrument rubric, instrument scoring criteria, and instrument recapitulation. The last section of the text comprised recommendations and a bibliography.

The next phase involved development. The stages of product development included preparing test instrument parts, consisting of three components. Instrument-shaped writing implements are digital assessments that include student identification, question instructions, and 2-tier 20 multiple choice questions put on Google Forms. The initial section comprises the personal information of the learners, while the subsequent section encompasses the questions.

An expert conducted a rigorous validity test after designing the instrument. This stage involved the evaluation of the instrument's validity by two highly knowledgeable physics education professionals with a specialization on the instrument development and also physics subject teachers. The evaluation covered three key aspects: construct, material, and language. The researchers used quantitative data in the form of Likert scale scores to assess the validity of the expert test results. Then, the researchers measured three different elements using the Likert scale, consisting of four response options: 1, 2, 3, and 4. Table 5 shows the results of the validity test.

Table 5. Test Instrument Expert Validity Results

Aspect	Expert			Max Score	Assessment Percentage	Category
	1	2	3			
Construct	27	30	30	36	80,3%	Highly valid
Material	32	34	35	36	93,4%	Highly valid
Language	9	10	12	12	89,6%	Highly valid
Average assessment percentage					87,7%	Highly valid

The validity test value from the constructed aspect is 80.3%, categorized as very high [9], and is valid with minor revisions. The material aspect is 93.4%, categorized as very high [9]; and is valid with minor revisions. The language aspect is 89.6%, categorized as very high [9]; and is valid with minor revision. The researchers revised the product based on the suggestions and improvements of the validator. After the revision, the researcher conducted a field trial to test the empirical validity and

reliability of the developed instrument. The researchers promoted the test after the three validators declared the product was valid. Then, the researchers involved 30 students of X-2 at SMAN 1 Kotabumi.

Analysis of empirical validity or the level of item fit using the Rasch model with the assistance of Ministep 5.6.2 software. Table 6 shows the results of the empirical validity analysis.

Table 6. Item Fit Analysis on Diagnostic Test Instruments

Measure	Outfit		PT-Measure Corr	Item
	MNSQ	ZSTD		
5.05	0.97	0.25	0.69	S18
0.68	1.26	0.71	0.43	S1
032	0.87	-0.12	0.45	S10
0.23	0.94	0.5	0.42	S14
0.18	1.26	0.64	0.29	S12
0.09	0.98	0.14	0.37	S4
-0.15	1.17	0.48	0.29	S15
-0.21	0.94	0.11	0.33	S5
-0.31	0.72	-0.28	0.33	S2
-0.31	1.01	0.23	0.29	S20
-0.37	0.83	-0.7	0.31	S6
-0.37	1.02	0.24	0.29	S17
-0.43	1.23	0.54	0.24	S11
-0.43	1.04	0.28	0.27	S16
-0.49	0.82	-0.5	0.30	S3
-0.49	0.89	0.6	0.26	S8
-0.49	0.74	-0.19	0.30	S13
-0.84	0.83	-0.6	0.26	S7
-0.84	0.66	-0.38	0.30	S9
-0.84	0.71	-0.28	0.26	S19

The outfit mean squared (Outfit MNSQ) value is in the interval 0.66 <MNSQ> 1.38, indicating the accurate measurement of the product to assess the students. The Outfit ZSTD value is -0.37<ZSTD>0.64, indicating the rational probability value of the data. The PT Measure Corr value is in the interval 0.24 <PT Measure Corr> 0.69, indicating the normal distribution of the data. Based on these three criteria, all items met the Rasch model.

The obtained analysis on item fit is in the form of item suitability based on Bond and Fox (2015): (1) the outfit mean square (MNSQ) value is accepted 0.5 < MNSQ < 1.5; (2) the Outfit Z-standard (ZSTD) value is accepted -2.0 < ZSTD < +2.0; (3) the Point Measure Corr value is accepted 0.4 < Pt Measure Corr < 0.85. If the test item meets at least one of the criteria, then the item or statement is applicable or valid. Azizah and Wahyuningsih also explain the determination of fit items must at least meet one of the criteria [10]. Based on these criteria, the items of the test instrument met one of the conditions so that the instrument was valid.

An instrument is reliable if the instrument shows the same results after being repeatedly used [14]. Reliability validity analysis using Rasch model with the assistance of Ministep 5.6.2 software. Table 7 shows the results of the empirical validity analysis.

Table 6. Item Reliability and Pearson Reliability Analyses

Analysis	Value	Question	Conclusion
Person Reliability	0.88	1-20	Average reliability
Item Reliability	0.95		
Alpha Cronbach	0.66		

The INFIT MNSQ and OUTFIT MNSQ values increase by 0.98 and 0.94 because these values are close to the ideal of 1.00 and INFIT ZSTD. The OUTFIT SZTD values increase by 0.06 and 0.12 because these values are close to the ideal of 0.00, so the reliability of the question items is excellent. Furthermore, the item reliability value is 0.95, meeting the special criteria [11]. The grouping of respondents on the item question is quite good, 4.27, indicating the capability of the item question to measure respondents with low to high abilities. Respondents' interaction with the question items is moderate because the Cronbach alpha value is 0.66, average. Tarigan et al also explain that high or low reliability is empirically indicated by a number called the reliability coefficient [12]. Based on item reliability, item reliability, and Conbach's alpha value, the two-tier diagnostic test instrument is acceptable. This is in line with Bond and Fox's statement that the item and respondent reliability index is acceptable if it is more than 0.8 [15]. The last stage is dissemination. After the test instrument is valid based on the experts and empirically valid and reliable, the developed instrument was declared a standardized product.

D. Conclusion

The development resulted in a two-tier diagnostic test instrument based on Google Forms, designed to measure student misconceptions about energy and various forms of energy. The instrument includes a grid, instructions for use, an instrument form, answer guidelines, and a score recapitulation. Experts declared the test instrument valid in terms of construct, substance, and language. The Minister 5.6.1 software found the two-tier diagnostic test instrument, based on Google Forms, to be empirically valid and reliable for measuring student misconceptions about energy and forms of energy based on the empirical validity standards in the very valid category and average category reliability.

Acknowledgments

The researcher would like to thank the 2020 physics education study program students who have provided assistance and motivation so that this research can be completed.

References

[1] Puspitasari, A. D. (2019). Penerapan media pembelajaran fisika menggunakan modul cetak dan modul elektronik pada siswa SMA. *Jurnal Pendidikan Fisika*, *7*(1), 17-25.

[2] Suparno, Paul. 2013. Miskonsepsi dan Perubahan Konsep dalam Pendidikan Fisika. Jakarta: PT Grasindo

[3] Ali, Muhammad. (2019). Analisis Miskonsepsi Siswa Berdasarkan Gender Dalam Pembelajaran Fisika Dengan Menggunakan Tes Diagnostik Two-Tier di Kotabaru. *Cendikia: Jurnal Ilmiah Pendidikan*. 7(1).59-66.

[4] Dasar, D. S. (2020). Asesmen Diagnostik. Direktorat Sekolah Dasar, Direktorat Jenderal PAUD Dikdas Dan Dikmen, Kementrian Pendidikan Dan Kebudayaan, Riset Dan Teknologi.

[5] Sahidu, H., Gunawan, G., Indriaturrahmi, I., & Astutik, F. (2017). Desain sistem e-assessment pada pembelajaran fisika di LPTK. *Jurnal Pendidikan Fisika dan Teknologi*, No 2. Vol 2.

[6] Khoiriyah, I. Z., Faizah, S. N., & Mubin, M. (2019). Efektivitas Metode Inquiry Learning Terhadap Hasil Belajar Ipa Pada Tema Energi dan Perubahannya. *At-Thullab: Jurnal Pendidikan Guru Madrasah Ibtidaiyah*, *3*(2), 52-62.

[7] Fitri, S., & Oktavianty, E. (2019). Remediasi Miskonsepsi Menggunakan Model Pembelajaran REACT Tentang Usaha Dan Energi Di SMA. *Jurnal Pendidikan dan Pembelajaran Khatulistiwa (JPPK)*, *8*(9)

[8] Pujiyati, P. (2018). *Pengembangan instrumen tes diagnostik two tier untuk mendeteksi miskonsepsi fisika peserta didik sma 3 mataram tahun ajaran 2017/2018* (Doctoral dissertation, Universitas Mataram).

[9] Arikunto, S (2012) Dasar-Dasar Evaluasi Pendidikan Edisi 2. Jakarta: Bumi Aksara.

[10] Azizah, A., & Wahyuningsih, S. Penggunaan Model Rasch Untuk Analisis Instrumen Tes Pada Mata Kuliah Matematika Aktuaria. *Jupitek*, *3*(1), 45-50.

[11] Sumintono, B., & Widhiarso, W. (2015). Aplikasi Pemodelan Rasch Pada Assessment Pendidikan. Cimahi: Tim komunikata.

[12] Tarigan, E. F., Nilmarito, S., Islamiyah, K., Darmana, A., & Suyanti, R. D. (2022). Analisis Instrumen Tes Menggunakan Rasch Model dan Software SPSS 22.0. *Jurnal Inovasi Pendidikan Kimia*, *16*(2), 92-96

[13] Thiagarajan, S., Semmel S.D and Semmel M.I. (1974). Instructional Development for Training Teachers of Exceptional Children. Minneapolis, Minnesota: Leadership Training Institute Education, University of Minesota.

[14] Rosidin, U. (2017). *Evaluasi Dan Asesmen Pembelajaran*. Media Akademi.
[15] Bond, T. G., & Fox, C. M. (2015). Applying the Rasch Model: Fundamental Measurement in the Human Sciences (3rd ed.). Mahwah, NJ: L. Erlbaum.

DOI: 10.14421/impulse.2024.41-04

IMPULSE: Journal of Research and Innovation in Physics Education
Volume 4, Issue 1, 31 – 37

© ISSN (p): 2798–1762; ISSN (e): 2798-1754
http://ejournal.uin-suka.ac.id/tarbiyah/impulse

Development of Pop-Up Book Based Learning Media on Optical Instruments Material in Senior High School/Islamic Senior High School

Laxmi Zahara[1], Siti Laili Khadijah[1], Badrul Wajdi[1]

[1] Science Education Study Program, Universitas Hamzanwadi, Indonesia
*Corresponding author: laxmizahara3@gmail.com

ABSTRACT

Learning media makes the teaching and learning process easier and increases students' interest in learning. This development research developed a pop-up book-based learning media on optical devices material for Senior High School/Islamic Senior High School. This type of research is research and development research. The development model used in this research is the 4D model: define, design, develop, and disseminate. Product testing of pop-up book-based learning media development applied validation from material experts and media experts, subject teachers and student response questionnaires. Technical analysis of data from the distribution of questionnaires was done by tabulating data from each validator and calculating the percentage. Data collection techniques use instruments in the form of interviews, sheets validation, questionnaire, and pretest-posttest. The researchers analyzed the obtained data using the formula for determine the percentage of product feasibility. Based on the assessment results of 2 material experts, 2 media experts and 2 teachers, it shows that pop up books are included in the very feasible category. Meanwhile, the student response assessment was included in the very good response category and the results of the effectiveness test showed the quite effective category.

INTISARI

Penelitian ini bertujuan untuk mengembangkan media pembelajaran berbasis pop-up book pada materi alat-alat optik untuk SMA/MA. Jenis penelitian ini adalah penelitian pengembangan research and developmen. Model pengembangan yang digunakan pada penelitian ini adalah model 4D, yaitu devine, design, develop, dan disseminate. Berdasarkan kebutuhan peneliti, prosedur pengembangan 4-D pada penelitian pengembangan ini hanya sampai pada tahap pengembangan (develop) dan di uji skala terbatas hal Ini karena adanya pertimbangan keadaan, waktu, dan biaya. Pengujian produk pengembangan media pembelajaran berbasis pop up book dilakukan melalui validasi dari ahli materi dan ahli media, guru mata pelajaran dan angket respon siswa. Teknis analisis data hasil penyebaran angket dilakukan dengan dengan tabulasi data dari masing-masing validator dan menghitung persentasenya. Berdasarkan hasil penilaian 2 ahli materi menunjukkan bahwa pop up book termasuk dalam kategori sangat layak, dengan persentase 89%. Sedangkan untuk hasil penilaian dari 2 ahli media menunjukkan bahwa pop up book termasuk

ARTICLE HISTORY
Received: May 24, 2024
Accepted: July 22, 2024

KEYWORDS:
Optical Instruments, Pop-up book based Learning Media

KATA KUNCI:
Alat Optik, Media Pembelajaran berbasis Pop-up book

* Corresponding author:
Laxmi Zahara, Science Education Study Program, Universitas Hamzanwadi, Indonesia
✉ laxmizahara3@gmail.com

dalam kategori sangat layak, dengan persentase 95%. Dan berdasarkan penilaian dari 2 guru mata pelajaran menunjukkan bahwa pop-up book termasuk dalam kategori sangat layak , dengan persentase 90%. Sedangkan penilaian dari respon siswa termasuk dalam kategori respon sangat baik dengan persentase nilai 95%. Dan dari hasil uji efektifitas menunjukan kategori cukup efektif dengan persentase 67%.

A. Introduction

Education is a very important need for every human being to increase the quality and sources of human energy so that they can keep up with the growth of the era and improve their abilities. Along with technological advances, the era's needs and demands for competencies that humans must have are increasingly developing. Along with the rapid growth of science and technology, every country is required to produce quality human energy sources. Education a process of developing each individual's self that lasts a lifetime, including the family environment, school environment, and community environment [1]. The teaching and learning process is a mechanism by schools to carry out the function of educational facilities. In the teaching and learning process, one of the teachers' abilities is to prepare varied learning media. Professional teachers not only need to prepare lesson materials, but are also required to be creative in using and developing learning media. According to Supriatna, creative teachers can develop imaginative designs by planning how the learning process will occur and how students will be involved in the learning process [2]. Learning media will facilitate interaction between teachers and students so that learning activities will be more effective and efficient. Learning media is an important factor in improving the quality of learning. Learning media functions to simplify complex concepts so that they can be easily digested, Apart from that, the absorption capacity of the five different human senses will be maximized if you combine the senses of sight, hearing and touch with appropriate media [3]. The learning media created must also be able to arouse students' curiosity. If you only listen to verbal information from the teacher, students will not understand the lesson well. Learning will be more meaningful if students are involved in seeing, touching, or experiencing it themselves through the media.

Muchlisa explains the implementation of pop up box media in physics subjects improved students' mean scores, effectively used in learning [4]. Apart from increasing the effectiveness of learning, pop-up media can also increase student learning motivation. Nurlaelah on the subject of light among junior high school students also found the effectiveness of pop-up book implementatio [5]. Kusuma regarding the feasibility of developing pop-up media in physics subjects showed feasible and useful results [6]. Therefore, Pop-up Books are applicable in physics learning to convey the content of learning material, Pop-up Books are a visual medium

that displays book pages containing three-dimensional information when opened, which are easy to understand. and easy for readers to understand.

Sutrisno explains physics learning should develop students' science process skills, seen as creative activities in an open attitude [7]. Hernawan [8] explains learning media is a component that plays a role in learning to facilitate students' understanding of concepts or processes. In this case, the media can play a role in replacing objects, symptoms of real events become something that students can observe in the classroom [8]. Therefore, learning media could facilitate the learning process and increase students' understanding.

Based on the results of an interview conducted with one of the teachers at Madrasah Aliyah (MA)/Islamic Senior High School Mualimat Nahdlatul Wathan Diniyah Islamiah (NWDI) Pancor, many students argued that physics subject is difficult to understand, and sometimes boring, so that not a few students have difficulty understanding it. The applied learning media is also less varied, and some students are always sleepy because physics lessons are always placed in the last hour before noon. The applied media is in the form of textbooks containing material and less attractive pictures. These make students less interested in reading. Based on the description, this research will focus on developing Pop-Up Book-based learning media for class XI students of MA Mualimat NWDI PANCOR.

B. Method

This Research & Development produces a product in the form of a Pop Up Book on Optical Instruments material and examines the effectiveness of the product [9]. This research also examines the product feasibility and effectiveness to develop and validate existing products or new products based on user needs analysis. The applied model in the research is the Four-D (4-D) development research model. This model consists of four stages, namely: define, design, development and dissemination.

Product trials were carried out by 2 material experts, 2 media experts and 2 subject teachers to determine the feasibility level of the product being developed. A limited trial was carried out by class XI Science students at MA Mu'allimat NWDI Pancor to find out user responses to the Pop Up Book product. The researchers collected the data with interviews, validation sheets, questionnaires, and pretest-posttest. The product eligibility criteria based on the percentage obtained are determined as follows.

Tabel 1. Eligibility Criteria

Score in percentage (%)	Eligibility Criteria
< 21%	Unworthy
21 - 40%	Not feasible
41 - 60%	Average
61 – 80%	Worthy

Next, the percentage of the results of filling out the response questionnaire by students is determined using the following formula.

$$P = \frac{F}{N} \times 100\% \quad (1)$$

Description
P = percentage of respondents' answers
F = number of respondents' answers
N = the sum of all ideal scores

Using a Likert scale with number 1 as the lowest score and number 5 as the highest score, the researchers determined the responses with these criteria.

Table 2. Conversion of Student Response Questionnaire Scores

Score	Eligibility Criteria
0% - 20%	Not responsive
21% - 40%	Lack of response
41% - 60%	Average response
61% - 80%	Adequate response
81% - 100%	Excellent response

C. Result and Discussion

The R&D produces a product in the form of pop-up book learning media using the 4D model. The carried stages out are: define, design, develop, and disseminate. During the definition stage, the researchers identified and analyzed problems using a beginning-to-end analysis and set learning objectives. The findings from this definition stage revealed problems that necessitated the development of learning media. At the design stage, there are several steps, such as selecting material, writing the contents of the pop-up book, and determining the details of the material presented in the pop-up book. The researchers arranged the pop-up book's contents to determine its design outline, encompasing the cover, foreword, table of contents, fundamental principles, learning objectives, concept map, a portion of the material's content, practice questions, summary, glossary, and bibliography.

After revisions by material experts, media experts, and subject teachers, the development stage produced a finished product in the form of a pop-up book. Material experts, media experts, and subject teachers validated the pop-up book to identify its shortcomings. Material experts, media experts, and subject teachers validate the pop-up book and then provide comments and suggestions, leading to the subsequent revision stage. We made revisions to refine and improve the pop-up book. The pop-

up book underwent testing on class XI Science 1 MA Mu'allimat NWDI Pancor students after the revision stage concluded. The researchers conducted a pop-up book trial to measure the students' reactions to the developed pop-up book, and the researchers also conducted a pretest-posttest to evaluate the efficacy of the pop-up book learning medium on optical instruments.

Table 3. The Development Test Data

Assessment Aspects	Percentage score	Category
Material expert	89%	Very worthy
Media expert	95%	Very worthy
Subject teachers	90%	Very worthy
Student response	95%	Very excellent response
Posttest-pretest	67%	Quite effective

The research results indicate that pop-up book-based learning media received an 89% rating from material experts. Media experts get a percentage of 95%, and subject teachers get a percentage of 90%. According to student responses, pop-up book-based learning media received a percentage score of 95%. Meanwhile, the pretest-posttest question sheet get a score of 67%. The result indicates that the pop-up book learning medium falls into the "appropriate" category for student use.

Putri's research, involved developing pop-up book media for third grade elementary school students, yielded similar results [10]. Modeong's research, focused on creating pop-up cards for VSD class students, yielded similar outcomes [11]. Setyaningrum's research delves into literature studies, demonstrating the potential of pop-up book media as a medium in the aftermath of the COVID-19 pandemic [12]. Hamzah's research, developed pop-up book media for class IV islamic elementary school students, falls into the category of suitable use [13]. Izzah's literature study on the use of pop-up book media revealed its suitability in fostering student curiosity, with elementary school students in grades I, II, and III achieving minimum standard mastery scores higher than average [14]. Suroiha conducted another study on the development of pop-up media to train students' critical thinking skills. The resulting pop-up book medium was suitable for use and could improve students' critical thinking skills [15].

Based on the results of a review of the research conducted, the feasibility of pop-up learning media from various development results shows a high level of creativity on the part of the authors. There are many difficulties to go through, step by step, in producing quality and useful products. Based on a series of development stages carried out, it demonstrates the authors' high motivation to produce quality products that are suitable for use. The researchers hope that this development will inspire other researchers to persist in creating high-quality and useful educational products.

D. Conclusion

The researchers draw the following conclusions based on the research and discussions conducted. Firstly, the outcomes of this research and development involve the creation of a pop-up book-based learning medium, utilizing a 4D model that encompasses 4 development stages: define, design, develop, and distribute. We developed a printed and shaped pop-up book in F4 size, containing material information and images. We created this pop-up book using Canva. We present this pop-up book in an engaging manner to pique students' interest in reading and utilizing it as a learning tool. According to criticism and suggestions from validators, pop-up book media is excellent to use. Secondly, the data analysis and discussion results indicate that material experts, media experts, and subject teachers deem pop-up books suitable for use. Additionally, the assessment of pop-up book students yields excellent responses, confirming the suitability of these books for use. The assessment results from material experts were 89%, those from media experts were 95%, and those from subject teachers were 90%. These scores fall within the range of 81–100%, indicating their feasibility, while the student response questionnaire yielded a percentage of 95% within the same range. This indicates that it falls into the category of outstanding responses. Thirdly, Pop-book-based learning media utilized on optical instruments. The developed material exhibits significant effectiveness. An increase in the pretest-to-posttest value from the N-gain percentage value of 67%, which falls into the quite effective category, proves this.

References

[1] Y. Alpian, S. W. Anggraeni, U. Wiharti, and N. M. Soleha, "Pentingnya Pendidikan Bagi Mnusia," *J. Buana Pengabdi.*, vol. 1, no. 1, pp. 66–72, 2019.

[2] Y. Fitriyani, N. Supriatna, and M. Z. Sari, "Pengembangan Kreativitas Guru dalam Pembelajaran Kreatif pada Mata Pelajaran IPS di Sekolah Dasar," *J. Kependidikan J. Has. Penelit. dan Kaji. Kepustakaan di Bid. Pendidikan, Pengajaran dan Pembelajaran*, vol. 7, no. 1, p. 97, 2021, doi: 10.33394/jk.v7i1.3462.

[3] A. Kristanto, *Media Pembelajaran*. Surabaya: Bintang Surabaya, 2016.

[4] N. Muchlisa, S. Anggereni, A. U. Dani, and S. Suhardiman, "Pengembangan Media Pembelajaran Pop Up Box Berbasis Problem Solving Pada Mata Pelajaran Ipa Fisika," *Al asma J. Islam. Educ.*, vol. 3, no. 1, p. 97, 2021, doi: 10.24252/asma.v3i1.21186.

[5] N. Nurlaelah, J. Sabaryati, and Z. Zulkarnain, "Pengembangan Media Pembelajaran Kotak Pop Up Untuk Mingkatkan Motivasi Belajar Siswa Materi Cahaya Dan Alat Optik Kelas Viii Smpn 19 Mataram," *ORBITA J. Kajian, Inov. dan Apl. Pendidik. Fis.*, vol. 5, no. 1, p. 15, 2019, doi: 10.31764/orbita.v5i1.895.

[6] W. Kusuma, G. M. Sihombing, E. B. Ramadhan, S. H. Hindiyati, L. Nuraini, and B. Supriadi, "Pengembangan Media Interaktif Pop Up Box Untuk Pembelajaran

Fisika Pada Materi Teori Model Atom Siswa SMA," *J. Ilm. Pendidik. Dasar*, vol. 8, no. 2, pp. 2531–2542, 2023.
[7] Sutrisno, *Fisika dan Pembelajarannya*. Bandung: Universitas Pendidikan Indonesia.
[8] A. H. Hernawan and Dewi Andriyani, "Hakikat Kurikulum dan Pembelajaran," *Modul Pembelajaran*, pp. 1–42, Jakarta: Universitas Terbuka: Jakarta, 2014,
[9] K. Keislaman, "The Concept of Research in Education," *Routledge Libr. Ed. Philos. Educ. 21 Vol. Set*, vol. 21, no. 1989, pp. 137–153, 2022, doi: 10.4324/9780367352035-10.
[10] Q. K. Putri, P. Pratjojo, and A. Wijayanti, "Pengembangan Media Buku Pop-Up untuk Meningkatkan Kemampuan Menyimak Tema Menyayangi Tumbuhan dan Hewan di Sekitar," *J. Pedagog. dan Pembelajaran*, vol. 2, no. 2, p. 169, 2019, doi: 10.23887/jp2.v2i2.17905.
[11] F. A. Modeong and A. A. D. Al Kahar, "Pengembangan Media Pop-Up Card pada Mata Pelajaran IPA Kelas V di Madrasah Ibtidaiyah," *J. Elem. Educ. Res.*, vol. 3, no. 2, pp. 93–106, 2023, doi: 10.30984/jeer.v3i2.709.
[12] R. Setiyanigrum, "Media Pop-Up Book sebagai Media Pembelajaran Pascapandemi," *Semin. Nas. Pascasarj. 2020*, no. 2016, pp. 2016–2020, 2020.
[13] L. Hamzah and M. A. Baalwi, "Pengembangan Media Pembelajaran Pop-Up Book Materi Keragaman Budaya Dengan Model Addie Pada Kelas IV MI Asasul Muttaqin," *Lintang Songo J. Pendidik.*, vol. 5, no. 1, pp. 26–31, 2022.
[14] A. N. Izzah and D. Setiawan, "Penggunaan media pop up book sebagai media belajar yang menyenangkan di rumah dalam inovasi pembelajaran sd kelas rendah," *Sinar Dunia J. Ris. Sos. Hum. Dan Ilmu Pendidik.*, vol. 2, no. 3, pp. 86–92, 2023.
[15] L. Suroiha, G. K. Dewi, and S. Wibowo, "Pengembangan Media Pop-Up Book terhadap Keterampilan Berpikir Kritis pada Siswa Sekolah Dasar," *Edukatif J. Ilmu Pendidik.*, vol. 4, no. 1, pp. 516–523, 2021, doi: 10.31004/edukatif.v4i1.1856.

DOI: 10.14421/impulse.2024.41-05

IMPULSE: Journal of Research and Innovation in Physics Education
Volume 4, Issue 1, 38 – 46

© ISSN (p): 2798–1762; ISSN (e): 2798-1754
http://ejournal.uin-suka.ac.id/tarbiyah/impulse

The Development of Problem-based Learning Worksheet for the Material of Optical Instruments

Khusnul Khotimah[1*]

[1] Department of Physics Education, UIN Sunan Kalijaga Yogyakarta, Indonesia
*Corresponding author: khusnulkh2661@gmail.com

ABSTRACT

Student learner-centered creates interaction and activeness of teaching and learning activities in the classroom. Students can play an active role in learning by using Problem-Based Learning (PBL) based student worksheets. This study aims to 1) Know the results of the development of student worksheets Problem-Based Learning (PBL) on optical instrument material, 2) Know the quality/feasibility of student worksheets Problem-Based Learning (PBL) on optical instrument material, 3) Know the response of students to student worksheets Problem-Based Learning (PBL) on optical equipment material. This research is a Research & Development using 4D development procedures by Thiagarajan. The development phase includes define, design, develop, and disseminate, but this research is limited to the develop stage by conducting limited and field tests. The product developed is a student worksheet based on Problem Based Learning (PBL) on optical instruments for high school students. The quality of student worksheets based on Problem-Based Learning (PBL) on optical instrument material for Senior High School class XI which was developed based on the assessment of material experts, media experts and physics teachers obtained Very Good (VG) criteria. The response of students to student worksheet in limited trials and field trials obtained Very Good (VG) criteria. These results show that student worksheets based on Problem-Based Learning (PBL) can be used as teaching material in the learning process on optical instrument materials.

INTISARI

Pembelajaran yang berorientasi pada peserta didik mendorong terciptanya interaksi dan keaktifan kegiatan belajar mengajar di kelas. Peserta didik dapat berperan aktif dalam pembelajaran dengan menggunakan Lembar Kerja Peserta Didik (LKPD) berbasis *Problem Based Learning* (PBL). Penelitian ini bertujuan untuk 1) Mengetahui hasil pengembangan LKPD *Problem Based Learning* (PBL) pada materi alat optik, 2) Mengetahui kualitas/kelayakan LKPD *Problem Based Learning* (PBL) pada materi alat optik, 3) Mengetahui respon peserta didik terhadap LKPD *Problem Based Learning* (PBL) pada materi Alat Optik. Penelitian ini merupakan penelitian pengembangan (*Research & Development*) menggunakan prosedur pengembangan 4D oleh Thiagarajan. Tahap pengembangan meliputi *define* (pendefinisian), *design* (perancangan), *develop*

ARTICLE HISTORY
Received: June 1, 2024
Accepted: July 30, 2024

KEYWORDS:
Optical Instruments, Problem-Based Learning, Student Worksheet

KATA KUNCI:
Alat Optik, Lembar Kerja Peserta Didik, Pembelajaran Berbasis Masalah

* Corresponding author:
Khusnul Khotimah, Department of Physics Education, UIN Sunan Kalijaga Yogyakarta, Indonesia
✉ khusnulkh2661@gmail.com

(pengembangan), dan *disseminate* (penyebaran), namun penelitian ini dibatasi sampai tahap *develop* (pengembangan) dengan melakukan uji coba terbatas dan uji luas. Hasil penelitian ini adalah LKPD berbasis *Problem Based Learning* (PBL*)* pada materi alat optik untuk peserta didik SMA/MA. Kualitas LKPD berbasis *Problem Based Learning* (PBL*)* pada materi alat optik untuk SMA/MA kelas XI yang dikembangkan berdasarkan pada penilaian ahli materi, ahli media dan guru fisika memperoleh kriteria Sangat Baik (SB). Respon peserta didik terhadap LKPD pada uji coba terbatas dan uji coba luas mendapatkan kriteria Sangat Baik (SB). Hasil tersebut menunjukkan bahwa LKPD berbasis *Problem Based Learning* (PBL) dapat digunakan sebagai bahan ajar dalam proses pembelajaran pada materi alat optik.

A. Introduction

Physics is a natural science that studies the nature, phenomena, and interactions of nature that have a significant impact on human life. However, physics is still considered difficult because of the many abstract equations and concepts, as well as the boring and incomprehensible learning traits of students [1]. The purpose of learning physics is to not only help students comprehend concepts and principles, but also to enhance their knowledge and confidence, preparing them for higher education. Additionally, students can learn life-enhancing science and technology.

Current learning still focuses on teachers as central figures in the educational process. In fact, the curriculum requires learner-centered learning to enhance students' active participation in the classroom [2]. One of the learning models that fosters student activeness is problem-based learning (PBL) [3]. Problem-Based Learning (PBL) presents students with real-life problems in order to encourage them to be more active and cooperative in collecting information, fostering independence, and developing critical thinking skills [4]. The implementation of this model requires guidelines containing activities to solve a problem in the form of teaching materials, namely Student Worksheets [5]. Teachers expect student worksheet to enhance students' critical thinking skills, information analysis, and ability to compile activity results [6]. student worksheet are student work guidelines that can facilitate the implementation of learning so that students master certain competencies. student worksheet is a tool that can help students understand concepts and build on the knowledge gained to create a positive learning environment [7].

An interview with a physics teacher at SMA N 10 Purworejo revealed that students still struggle with optical instruments, particularly loupes and binoculars. The most difficult part is determining magnification with a microscope and binoculars. This is due to the memorization of concepts and calculations, rather than a thorough understanding. The limited availability of optical instruments in schools has led to a learning process that primarily focuses on theoretical concepts. In fact, optics is part of physics that is close to everyday life [8]. Students still need a direct picture of optical instruments, such as binoculars' original shape. Teachers still use teaching

materials like text books and student worksheets, but they haven't utilized them to their full potential. Student worksheet contains concise material and practice questions that are not mastered by students, so they are unable to solve inquiries well. In addition, the physics teacher at SMA N 10 Purworejo reports that students exhibit a preference for the approach that facilitates problem-based learning. This is supported by Hendrayani's research [9], which shows that problem-based learning (PBL) effectively gives learners the freedom to work through their own problems and conduct research so as to improve their understanding of concepts.

The distribution of questionnaires to students at SMA N 10 Purworejo reveals that the use of teaching materials (textbooks and student worksheet) in physics learning has not reached its full potential. The Student worksheet used in physics learning is colorless and less attractive, so students feel bored with it. The lack of completeness in the presentation of optical instrument material in student worksheet causes difficulties for students in understanding the concepts taught. Additional problems arise because the level of difficulty of the practice questions given by the teacher is not in line with the example questions contained in the textbook and Student worksheet, making it difficult for students to do them. When the teacher presents material solely based on similarities, students often memorize it without comprehending the concepts, leading to easy forgetting. In addition, students consider optical instrument material to be one of the more difficult materials, especially in determining shadow formation and calculating magnification in optical instruments. Due to the limited availability of optical instruments and the infrequent practicum activities, students often struggle to understand the material and struggle to solve problems related to their daily lives.

Based on the observations, the student worksheet was colorless, limited compatible images with optical instrument materials such as loupes, binoculars, microscopes, and cameras. student worksheet contains a design for an experiment to find the correlation between distance, shadow distance, and focal distance in convex and concave lenses, but there are no experimental steps. This prevents students from conducting experiments on student worksheet, thereby reducing their proficiency in using optical instruments.

The aforementioned issues demonstrate the need for teaching materials that not only facilitate learning but also cater to the specific needs of students when it comes to physics instruction on optical instruments. Additionally, we anticipate that these materials will aid students in comprehending the subject matter. The focus of this research will be the "Development of student worksheet Based on Problem-Based Learning (PBL) on Optical Instruments Materials."

B. Method

This research employs the research and development (R&D) method to develop new products. Thiagarajan [10] introduced the 4D model, comprising four stages: define, design, develop, and disseminate. In this study, the stages of product development are limited to the development stage, the extensive trials. The development research culminated in the creation of a student worksheet by utilizing problem-based learning (PBL) on optical instrument material.

The researchers used non-test instruments such as interview sheets, questionnaire sheets, instrument validation sheets, program validation sheets, assessment sheets, and student response sheets for data collection. This study yielded two types of data: qualitative and quantitative. Qualitative data includes input and suggestions from the validation and assessment process (material experts, media experts, and physics teachers). Material experts, media experts, and physics teachers combine quantitative data, or numerical data from measurements or observations, with qualitative data on the assessment sheet for evaluation.

The applied data analysis is qualitative and quantitative. Qualitative descriptive data analysis describes the results of interviews and advice from experts [11]. Expert validation, expert assessment, and student responses to the developed product serve as the basis for quantitative descriptive data analysis, which determines the level of product quality [11]. The researchers carried out quantitative descriptive data analysis by processing data in the form of numbers obtained through questionnaires.

The validation instrument used by media experts and material experts is a questionnaire with questions compiled by the researcher himself. Calculating validity with Aiken's V [12] according to equation 1:

$$V = \frac{\Sigma s}{[n(c-1)]} \quad \text{with } s = r - l_0 \tag{1}$$

Information:

L_0 = Lowest scoring score
c = Highest scoring score
r = Score given by the rater
n = Number of experts assessing

Table 1. Average Score Percentage Criteria

Score Percentage (V)	Criteria
V≤0,5	Invalid
V>0,5	Valid

Product eligibility is assessed using a Likert scale with a maximum score of four and a minimum score of one. The final score is generated by summing all indicator scores and then averaging them to establish the percentage of product viability [13]. Table 1.2 shows the range of assessment scores. Equation 2 is used to calculate the average assessment score from physics experts and teachers [14].

$$X_{average} = \frac{\sum x}{N.n} \quad (2)$$

Information:

$X_{average}$ = Average score
$\sum x$ = Total score obtained from research
N = Number of Assessors
n = Number of questions

Table 2. Criteria for Average Percentage Score

Percentage	Criteria
1,00 – 1,75	Very Not Good (Poor)
1,76 – 2,50	Low Good (Under average)
2,56 – 3,25	Good (Excellent)
3,26 – 4,00	Very Good (Extremely Excellent)

Student response scoring is assessed using a Likert scale with a maximum score of four and a minimum score of one. To analyze the response of learners can use equation 3. The results of the percentage of learner responses are then interpreted in qualitative statements based on table 2.

C. Result and Discussion

This development research produces teaching materials in the form of student worksheet based on Problem-Based Learning (PBL) on optical instrument materials. This research uses Thiagarajan's 4D model (define, design, development, disseminate) and is limited to the development stage with extensive testing. The define stage is the first step to determine the needs of the learning process and analyze it appropriately. Needs analysis was obtained from teacher interviews and dissemination of preliminary study questionnaires to students.

The second stage is design with three main activities, namely media selection, format selection and product initial design. First, media selection identifies the right learning media with the characteristics of the material and according to the needs of students. Second, in choosing the format of teaching materials that are adjusted to the results of needs in the form of student worksheet based on Problem-Based Learning (PBL) on optical tool materials. The sections of student worksheet are adapted from

Elfina & Sylvia's research [15], including the title of student worksheet, subjects to be taken, semesters, places, study instructions, competencies to be achieved, learning indicators, supporting information, tools and materials in working on student worksheet, work steps, and assessments. Third, namely the preparation of the initial design of the product. The initial design of student worksheet is prepared in Canva and the steps of student worksheet activities based on Problem-Based Learning (PBL). In the manufacture of student worksheet products with instructions for use, experimental activities, and pictures of optical instruments.

The third stage is development with two activities, namely expert appraisal and developmental testing. Expert appraisal is an activity to validate and assess the feasibility of product design carried out by experts in their fields. For example, its activities are validation and assessment of product development. Developmental testing is a product design trial activity that involves actual subjects. Examples of activities are student response tests.

The development stage includes validation to create a final product that undergoes validity testing. The validation stages include instrument validation and student worksheet product validation. Instrument validation involves two instrument experts, and student worksheet product validation involves two material experts and two media experts. The instrument validation results are declared. The instrument is declared valid with an Aiken's V coefficient value of 0.90. This suggests that future use of the instrument is possible. In the expert validation phase, the material comprises 21 statements that address various aspects such as core competencies and basic competencies, the veracity of a concept or material, language and writing skills, presentation systematics, and problem-based learning (PBL). The media validation consists of 11 statements covering the display aspect. The material expert validation results are as follows:

Table 3. Material Expert Validation Results

Aspect	Aiken's V	Criteria
Material Aspect with KI and KD	1.00	Valid
Aspect of The Truth of A Concept/Material	0.91	Valid
Aspect of Language and Writing	0.95	Valid
Supporting Aspects of Learning Materials	0.88	Valid
Aspect of Presentation Systematics	1.00	Valid
Aspect of Problem-Based Learning (PBL)	1.00	Valid
Average	0.96	

Table 4. Media Expert Validation Results

Aspect	Aiken's V	Criteria
Display Aspect	0.92	Valid
Average	0.92	

Product quality assessment determined whether the revised product 1 was feasible or not based on the assessment of material experts, media experts and teachers. The following are the results of material expert assessments, media expert assessments and teacher assessments.

Table 5. Material Expert Assessment

Aspect	Aiken's V	Criteria
Material Aspect with KI and KD	3.67	Very Excellent
Aspect of The Truth of A Concept/Material	3.25	Excellent
Aspect of Language and Writing	3.00	Excellent
Supporting Aspects of Learning Materials	3.33	Excellent
Aspect of Presentation Systematics	3.25	Excellent
Aspect of Problem-Based Learning (PBL)	3.21	Excellent
Average	3.21	

Table 6. Media Expert Assessment

Aspect	Aiken's V	Criteria
Display Aspect	3.36	Very Excellent
Average	3.36	

Table 7. Teacher Assessment

Aspect	Aiken's V	Criteria
Material feasibility aspect	4.00	Very Excellent
Aspect of material accuracy	4.00	Very Excellent
Aspects of material presentation	3.66	Very Excellent
The graphic aspect	3.66	Very Excellent
Aspect of Problem-Based Learning (PBL)	4.00	Very Excellent
Average	3.83	

Problem-based learning (PBL) products, developed by material experts, media experts, and physics teachers, undergo a quality assessment stage. The researchers conducted both limited and extensive trials as part of the trial process. Here are the results of limited and extensive trials.

Table 8. Limited Trials

Aspect	Aiken's V	Criteria
User Friendly Aspect	3.41	Very Excellent
Display Aspect	3.38	Very Excellent
Average	3.39	

Table 9. Extensive Trials

Aspect	Aiken's V	Criteria
User Friendly Aspect	3.24	Excellent
Display Aspect	3.13	Excellent
Average	3.18	

D. Conclusion

This research generates a student worksheet that utilizes problem-based learning (PBL) with an emphasis on optical instrument materials. The developed student worksheet, based on Problem-Based Learning (PBL), exhibits a very excellent quality (VG) rating proved by the assessment of material experts, media experts, and physics teachers, with the obtained category of Very Excellent (VG) with means of 3.56, 3.28, and 3.86. Student responses to the student worksheet based on Problem-Based Learning (PBL), developed in limited trials and broad trials, fall under the Very Excellent (VG) criteria based on the mean scores: 3.4 in limited trials and 3.2 in extensive trials.

References

[1] Y. Trianah, "Pengembangan Lembar Kerja Siswa Kimia Berbasis *Problem Based Learning* untuk Meningkatkan Partisipasi dan Hasil Belajar Siswa SMA Kelas X," *J. Pendidik. Mipa*, vol. 11, no. 2, pp. 105–112, 2021, doi: 10.37630/jpm.v11i2.500.

[2] Y. D. Kristanti, Subiki dan R. D. Handayani "Model Pembelajaran Berbasis Proyek (*Project Based Learning*) pada Pembelajaran Fisika di SMA," *J. Pembelajaran* Fisika, vol. 5, no. 2, pp. 122–128, 2016.

[3] I. Febrita and Harni, "Model *Problem Based Learning* dalam Pembelajaran Tematik Terpadu terhadap Berfikir Kritis Siswa di Kelas IV SD," *J. Pendidik. Tambusai*, vol. 4, no. 2, pp. 1619–1633, 2020.

[4] U. Saharsa, M. Qaddafi, dan Baharuddin, "Efektivitas Penerapan Model Pembelajaran *Problem Based Learning* Berbantuan Video Based Laboratory Terhadap Peningkatan Pemahaman Konsep Fisika," *J. Pendidik. Fis.*, vol. 6, no. 2, pp. 57–64, 2018.

[5] Novita Ardian Krisgiyanti and A. T. Pratama, "Pengembangan Lembar Kegiatan Peserta Didik (Student Worksheet) Berbasis *Problem Based Learning* (PBL) pada Materi Sistem Regulasi dengan Orientasi Hasil Belajar Peserta Didik SMA N 1 Kroya," *J. Edukasi Biol.*, vol. 8, no. 1, pp. 46–56, 2022.

[6] U. Umaroh, Novaliyosi, and Y. Setiani, "Pengembangan Lembar Kerja Peserta Didik Elektronik (E-Student Worksheet) Berbasis *Problem Based Learning* (PBL) untuk Memfasilitasi Kemampuan Penalaran Peserta Didik pada Materi Lingkaran," *Wilangan: Jurnal Inovasi dan Pendidikan Fisika*, vol. 3, no. 1, pp. 61–70, 2022.

[7] A. A. Jawadiyah and Muchlis, “Pengembangan Student Worksheet Berbasis *Problem Based Learning* untuk Melatihkan Keterampilan Berpikir Kritis pada Materi Larutan Penyangga,” *UNESA J. Chem. Educ.*, vol. 10, no. 2, pp. 195–204, 2021.
[8] N. A. Himawan and I. Wilujeng, "Improving students’ problem-solving skills through quick on the draw model assisted by the optical learning book integrated the Pancasila", *J. Phys.: Conf. Ser.* 1440 012031, 2020
[9] A. Hendrayani, “Pengembangan Student Workhseet Berbasis *Problem Based Learning* Berbantuan Live Worksheet pada Materi Alat Optik,” Pekanbaru: Universitas Islam Negeri Sultan Syarif Kasim Riau, 2022.
[10] Thiagarajan, *Instructional Development for Training Teachers of Exceptional Children: A Sourcebook.* Bloomington: Indiana Univ., 1974.
[11] A. R. Supriatna, R. Siregar, and H. D. Nurrahma, “Pengembangan E-Student Worksheet Berbasis *Problem Based Learning* pada Muatan Pelajaran Matematika pada Website Live Worksheets di Sekolah Dasar,” *Edukatif J. Ilmu Pendidik.*, vol. 4, no. 3, pp. 4025–4035, 2022, doi: 10.31004/edukatif.v4i3.2844.
[12] Azwar, S. (2012). *Reliabilitas dan Validitas (4thed.)*. Yogyakarta: Pustaka Pelajar.
[13] Sugiyono, *Metode Penelitian Kuantitatif Kualitatif Ddan R&D*. Bandung: Alfabeta, 2013.
[14] Widoyoko. (2012). *Teknik Penyusunan Instrumen Penelitian.* Yogyakarta: Pustaka Pelajar
[15] S. Elfina and I. Sylvia, “Pengembangan Lembar Kerja Peserta Didik (Student Worksheet) Berbasis *Problem Based Learning* (PBL) dalam Meningkatkan Kemampuan Berpikir Kritis Siswa pada Mata Pelajaran Sosiologi di SMA Negeri 1 Payakumbuh,” *J. Sikola J. Kaji. Pendidik. dan Pembelajaran*, vol. 2, no. 1, pp. 27–34, 2020, doi: 10.24036/sikola.v2i1.56.

DOI: 10.14421/impulse.2024.41-06

IMPULSE: Journal of Research and Innovation in Physics Education
Volume 4, Issue 1, 47 – 60

© ISSN (p): 2798–1762; ISSN (e): 2798-1754
http://ejournal.uin-suka.ac.id/tarbiyah/impulse

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

ARTICLE HISTORY
Received: April 2, 2024
Accepted: August 30, 2024

KEYWORDS:

E-Student Worksheet, Momentum and Impulse, PhET Simulation

KATA KUNCI:

E-LKPD, Momentum dan Impuls, Simulasi PhET

* 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.

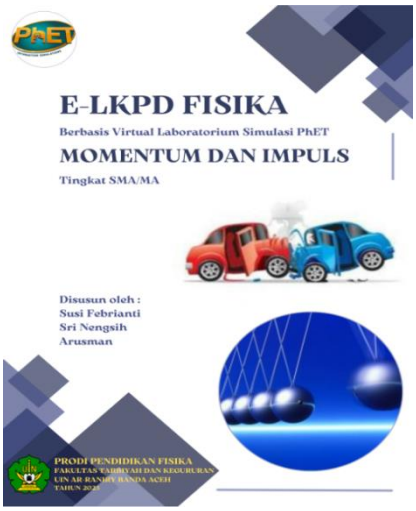


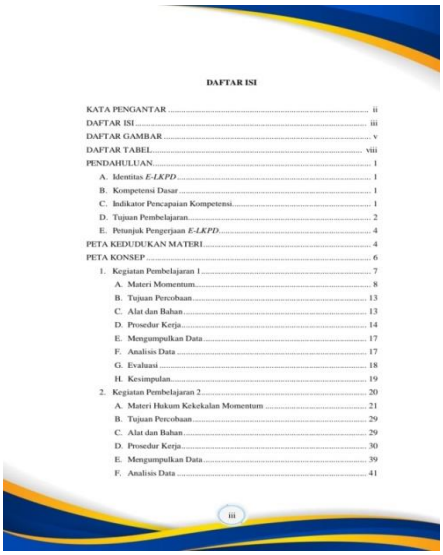
Figure 1. The Cover Page

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

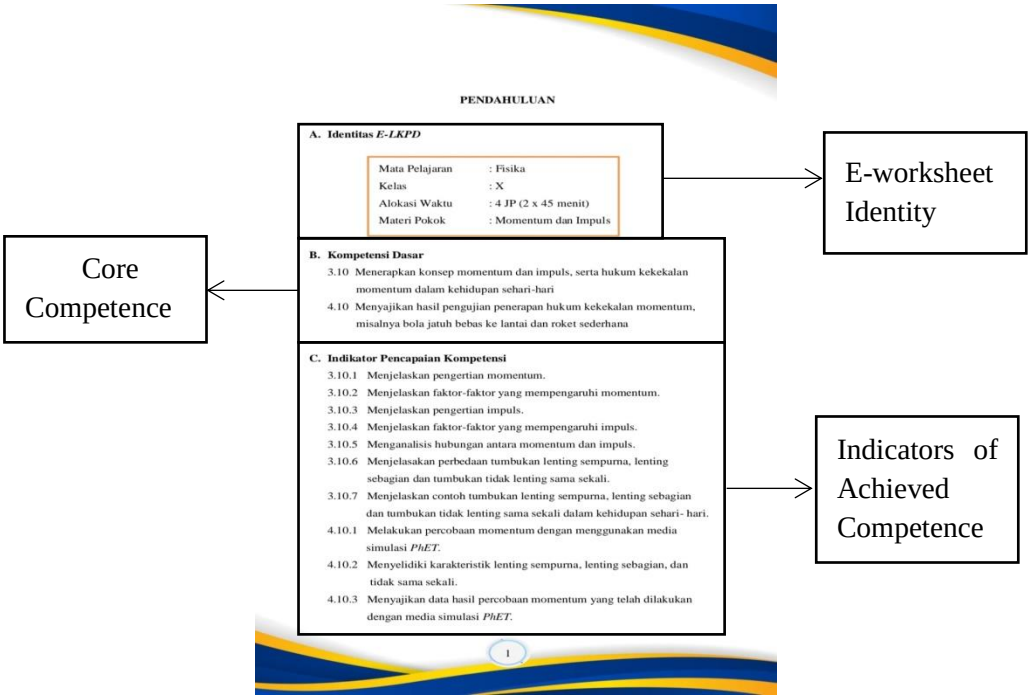
The figure list page consists of the figures of the e-worksheet to show the page sites of the figures in the e-worksheet.

e. The Table List Page

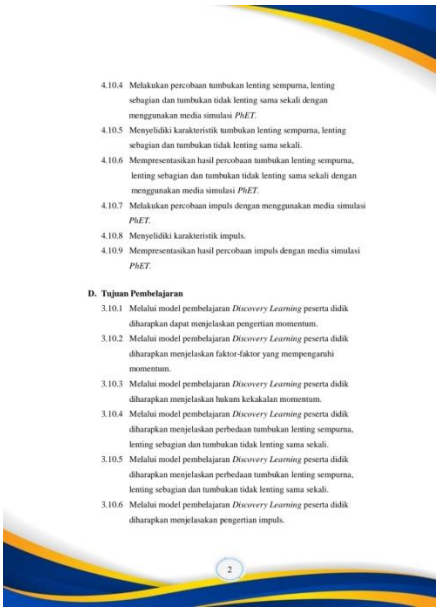
This page shows the parts of the tables in the e-worksheet, the function to show the page sites of the table parts.

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.

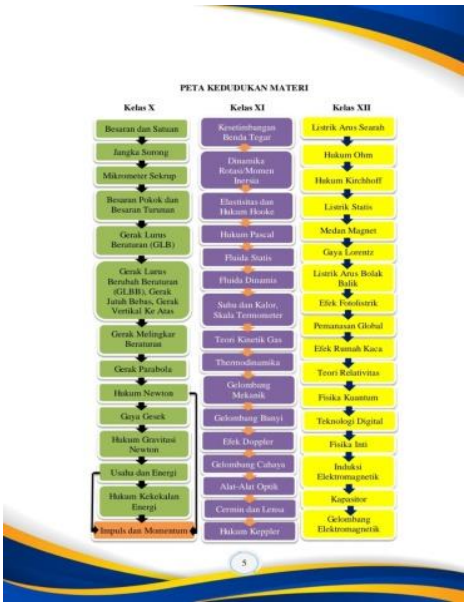


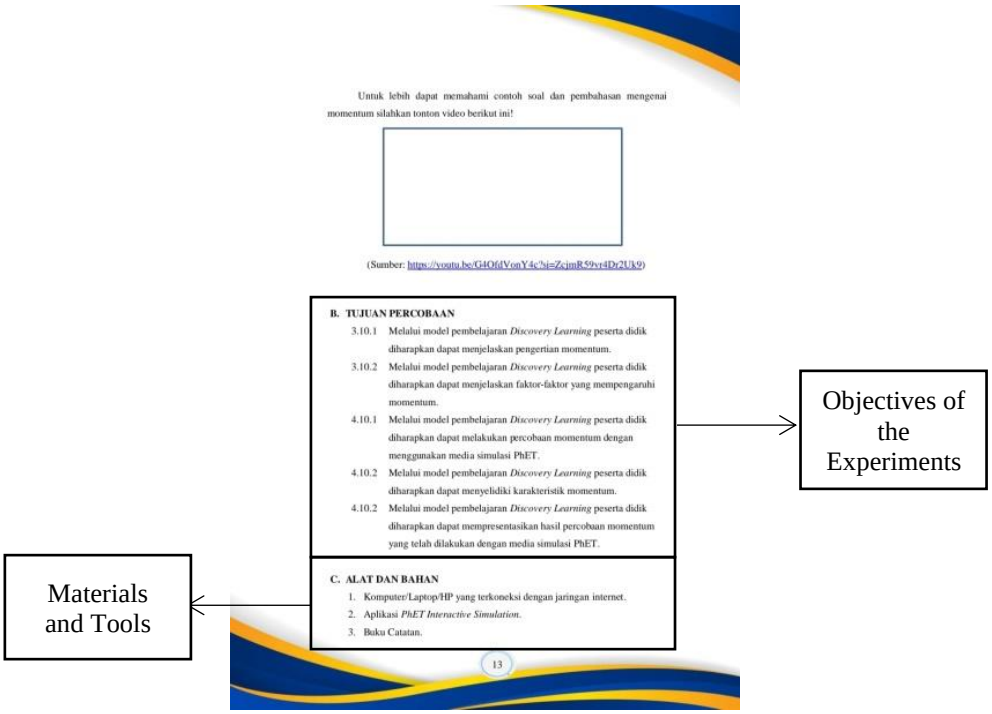
Figure 4. The Mapping Page of the Materials

h. The Conceptual Map Page

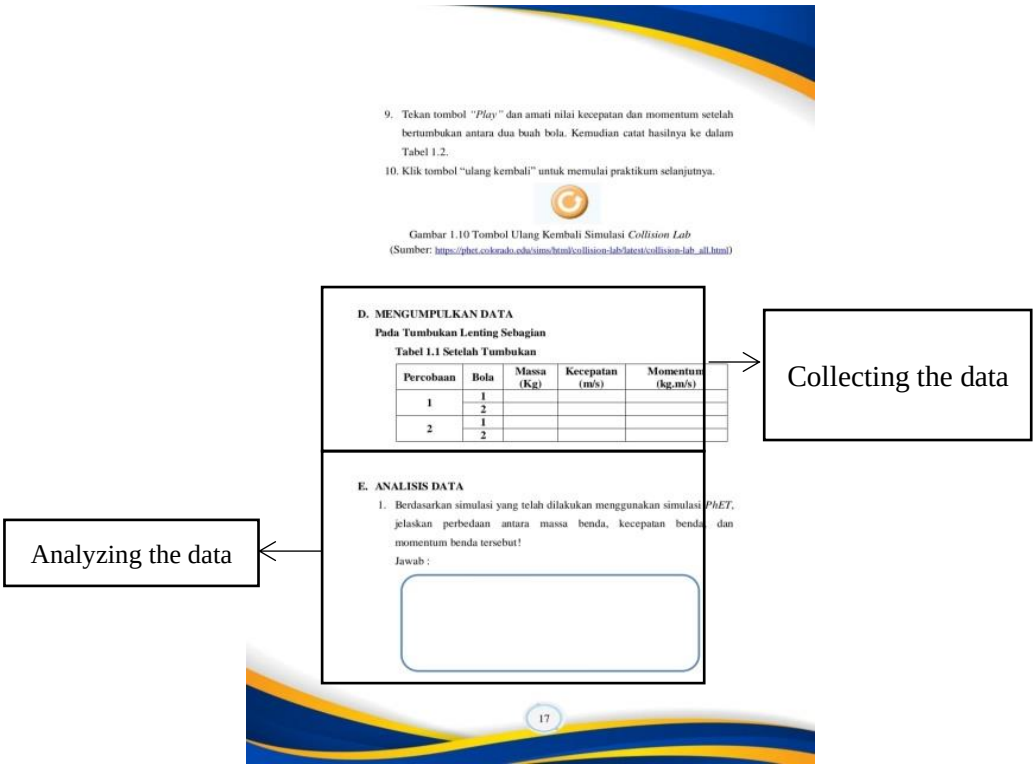
This page consists of the flowchart of the materials to describe the materials accurately.

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.

References

[1] S. Arikunto, *Prosedur Penelitian Suatu Pendekatan Praktik*. Jakarta: Rhineka Cipta, 2006.

[2] D. N. Syahputri, F. Solikhin, and N. Nurhamidah, "Pengembangan e-LKPD Berbasis Discovery Learning untuk Meningkatkan Pemahaman Peserta Didik pada Materi Reaksi Redoks," *Jurnal Inovasi Pendidikan Kimia*, vol. 17, no. 1, pp. 67–74, 2023, doi: 10.15294/jipk.v17i1.37598.

[3] V. Harvina, E. Hafid, and M. Rusydi Rasyid, "Pengaruh Manajemen Kelas dan Pengelolaan Media Pembelajaran Terhadap Kualitas Pendidikan," *Nazzama: Journal of Management Education*, vol. 1, no. 2, pp. 147–156, 2022, doi: 10.24252/jme.v1i2.28010.

[4] S. N. Hantika and Supahar, "Pengembangan LKPD Berbasis Relating, Experiencing, Applying, Cooperating, Transfering (REACT) Berbantuan PhET Simulation Untuk Meningkatkan Penguasaan Materi dan Keterampilan Proses Sains Peserta Didik SMA," *Jurnal Pendidikan Fisika*, vol. 8, pp. 1–11, 2021, doi: 10.21831/jpf.v8i4.17878.

[5] I. P. Admadja and E. Marpanaji, "Pengembangan Multimedia Pembelajaran Praktik Individu Instrumen Pokok Dasar Siswa SMK di Bidang Keahlian Karawitan," *Jurnal Pendidikan Vokasi*, vol. 6, no. 2, pp. 173–183, 2016, doi: 10.21831/jpv.v6i2.8107.

[6] M. Oktaviana, D. H. Putri, and E. Risdianto, "Pengembangan Modul Elektronik Berbantuan Simulasi PhET pada Pokok Bahasan Gerak Harmonik Sederhana di SMA," *Jurnal Kumparan Fisika*, vol. 3, no. 2, pp. 131–140, Aug. 2020, doi: 10.33369/jkf.3.2.131-140.

[7] N. Nafrianti, Z. A. I. Supardi, and Erman, "Pengembangan Perangkat Pembelajaran Inkuiri Terbimbing Berbantuan PhET pada Materi Listrik Dinamis untuk Meningkatkan Keterampilan Berpikir Kritis Siswa," *Jurnal Penelitian Pendidikan Sains*, vol. 6, no. 1, pp. 1100–1106, 2016, doi: 10.26740/jpps.v6n1.p1100-1106.

[8] O. D. Lestari and Suyoso, "Pengembangan LKPD Berbasis Problem Based Learning pada Materi Impuls dan Momentum," *Jurnal Pendidikan Fisika*, vol. 7, no. 1, pp. 12–7, 2018, doi: 10.21831/jpf.v7i1.10476.

[9] R. D. M. Rina Dwi Muliani and A. Arusman, "Faktor-Faktor yang Mempengaruhi Minat Belajar Peserta Didik," *Jurnal Riset dan Pengabdian Masyarakat*, vol. 2, no. 2, pp. 133–139, 2022, doi: 10.22373/jrpm.v2i2.1684.

[10] R. Nafaida, A. Halim, and S. Rizal, "Pengembangan Modul Berbasis PhET untuk Meningkatkan Pemahaman Konsep dan Motivasi Belajar Siswa pada Materi Pembiasan Cahaya," *Jurnal Pendidikan Sains Indonesia*, vol. 3, no. 1, pp. 181–185, 2015, [Online]. Available: http://jurnal.unsyiah.ac.id/jpsi

[11] S. S. Meisyaroh and Supahar, "Pengembangan LKPD Berbantuan PhET Simulation untuk Meningkatkan Kemandirian Belajar dan Berpikir Kritis," *Jurnal Pendidikan Fisika*, vol. 9, no. 2, pp. 85–104, 2022, doi: 10.21831/jpf.v9i2.18696.

[12] S. I. Masita, P. B. Donuata, A. A. Ete, and M. E. Rusdin, "Penggunaan Phet Simulation dalam Meningkatan Pemahaman Konsep Fisika Peserta Didik," *Jurnal Penelitian Pendidikan Fisika*, vol. 5, no. 2, pp. 136–141, 2020, doi: 10.36709/jipfi.v5i2.12900.

[13] N. A. Himawan and Ariswan, “Development of E-Module Momentum and Impulse Integrated the Pancasila Values Practice,” in *Proceedings of the 7th International Conference on Research, Implementation, and Education of Mathematics and Sciences (ICRIEMS 2020)*, Yogyakarta: Atlantis Press, 2021, pp. 567–572. doi: 10.2991/assehr.k.210305.083.
[14] N. A. Himawan and Ariswan, “Physics Learning E-Module Integrated with Practicing Pancasila Values on Momentum and Impulse: Is it Effective to Improve Students" Critical Thinking Skill and Hard Work Character?,” *Jurnal Ilmu Pendidikan Fisika*, vol. 8, no. 1, pp. 30–41, 2023, doi: 10.26737/jipf.v8i1.3128.
[15] Sugiyono, *Metode Penelitian dan Pendidikan Pendekatan Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta, 2010.

Published by
Pendidikan Fisika
UIN Sunan Kalijaga Yogyakarta