DEVELOPMENT OF A DISCOVERY LEARNING E-MODULE ASSISTED BY PHET SIMULATION FOR SOUND WAVE MATERIAL

Sabaruddin
Universitas Islam Negeri Ar-Raniry Banda Aceh
sabaruddin@ar-raniry.ac.id

Fauriza Hafni
Universitas Islam Negeri Ar-Raniry Banda Aceh
200204005@student.ar-raniry.ac.id

Fitriyawany
Universitas Islam Negeri Ar-Raniry Banda Aceh
fitriyawany@ar-raniry.ac.id

Abstract
This research is motivated by the use of teaching materials that are not varied, and the discussion of physics material is considered difficult due to students' lack of critical thinking. This resulted in students having difficulty understanding the concepts and equations contained in the sound wave material, thus requiring an appropriate learning model, namely discovery learning, where students are expected to overcome the problems faced. So, the development of e-modules based on discovery learning was assisted by Physics Education Technology (PhET) Simulation as a substitute for actual practicum. This study aims to determine the design, feasibility, and practicality of discovery learning-based physics learning e-modules assisted by PhET Simulation on sound wave material. The Alessi and Trollip development model guides an e-module based on discovery learning assisted by PhET Simulation because it is suitable for use in this research model. The resulting product is in electronic form and has three stages, namely: (1) Planning, (2) Design, and (3) Development. The product produced from this research is a learning e-module. Based on the alpha test of media and material experts with a very feasible category of 94.09% and based on the beta test getting a value of 93.92% very feasible category. So, e-modules based on discovery learning assisted by PhET Simulation can be used as physics learning materials on sound wave material, this e-module product can accelerate and clarify abstract theories on sound wave material for students' understanding. The study refers to one material in physics lessons at school, the object of research is still lacking, in the future it can expand the study on other physics materials and expand or increase data for beta testing by manipulating other research variables.

Keywords: E-Module, Discovery Learning, PhET Simulation, Sound Waves Material.

INTRODUCTION

Effective learning is one of the key factors in achieving educational goals. One approach that has been proven effective is the Discovery Learning method,[1] where learners are actively involved in the learning process through exploration and discovery of new concepts. This method

[1] Suari, Bagus Andika, and I Gede Astawan. 2021. "Efektivitas Model Discovery Learning Terhadap Hasil Belajar IPA". *Jurnal Penelitian Dan Pengembangan Pendidikan* 5 (2):270-77. https://doi.org/10.23887/jppp.v5i2.36980.

not only improves conceptual understanding but also develops critical thinking and problem-solving skills.[2]

However, in the context of physics learning, especially on sound waves, the application of the Discovery Learning method often faces obstacles. One of the main obstacles is the limited resources and learning media that are interactive and support the process of independent exploration. Conventional textbooks and lecture methods are often insufficient to explain abstract concepts such as sound waves in a way that is easily understood by learners.[3]

Along with the development of technology, there are various learning aids that can overcome this obstacle. One potential tool is technology-based simulations, such as Physics Education Technology (PhET) Simulation, developed by the University of Colorado Boulder, is one of the simulations that can be used to help explain physics concepts in an interactive and engaging way.[4] It allows learners to conduct virtual experiments, observe phenomena directly, and understand physics concepts in a more in-depth way.

A physics learning e-module will be developed in this research. According to the findings of open observations and interviews with one of the teachers at the school, the teacher only relied on printed books during the learning process. Physics is considered a fairly scary subject because students are less able to think critically. Students avoid asking about things they do not understand because of fear. This course makes teachers think about choosing the best learning model. The government hopes this curriculum will have interactive learning material and meet current standards.

Changing the physics learning atmosphere so that it involves students and provides more effective teaching is the best way to solve problems that aim to improve students' critical thinking abilities in physics lessons. To overcome this problem, teachers must use e-modules to teach in class. However, the E-module based on the discovery learning model has many advantages, including providing personalized information and penetrating students' memories.[5] Currently, there is PhET Simulation, which increases students' enthusiasm for learning by replacing real laboratories with visual laboratories. Thus, the development of E-module based on the discovery learning assisted by PhET Simulation is expected to be a solution to improve the quality of learning sound waves material. This e-module will be designed to facilitate the exploration and discovery of sound wave concepts independently by students, as well as provide a more interactive and enjoyable learning experience.

Much research has been done related to the use of PhET simulation and discovery learning. The results of observations carried out at Senior High School (SMA) Muhammadiyah 09 Kualuh Hulu, showed that sound wave material was one of the most difficult basic competencies for students and teachers during the even semester. This is the reason researchers want to create a

[2] Laeni, Sujatul, Zulkarnaen Zulkarnaen, and Shelly Efwinda. 2022. "Model Discovery Learning Terhadap Kemampuan Berpikir Kritis Siswa SMA Negeri 13 Samarinda Materi Impuls Dan Momentum". *Jurnal Literasi Pendidikan Fisika (JLPF)* 3 (2), 105-15. https://doi.org/10.30872/jlpf.v3i2.935.

[3] Putri, Meliani, Noviandra Azzahra, Wangi Dema Lestari, and Arini. 2024. "Implementasi Inovasi Pembelajaran Berbasis Discovery Learning Melalui Pemanfaatan Media Pembelajaran Secara Efektif Di SDN Bojong Kiharib". *Karimah Tauhid* 3 (3):3449-57. https://doi.org/10.30997/karimahtauhid.v3i3.12570.

[4] Syarifah Rahmiza Muzana, Silvi Puspa Widya Lubis, dan Wirda, "Penggunaan *Simulasi PhET* Terhadap Efektivitas Belajar IPA," *Jurnal Dedikasi Pendidikan*. vol 5, no. 1 (2021): 227–236.

[5] Asnita Asnita dan Erizal Gani, "Pengaruh Penggunaan Model *Discovery Learning* Terhadap Keterampilan Menulis Teks Eksplanasi Siswa Kelas Viii Smp Negeri 20 Padang," *Pendidikan Bahasa Indonesi.* vol 9, no. 1 (2020): 23.

discovery-based physics learning e-module with the help of PhET simulations to solve this problem.

Research conducted by Saparuddin et al. used a pre-experimental method with a single-group model. The pre-test obtained an average of 63 points, while the post-test obtained an average of 87 points. N-Gain test, which produces high-category data for student learning outcomes. This shows that using e-modules based on learning findings in a classroom approach can improve students' cognitive abilities.[6] Subsequent research by Novita Riskyka Sari Bukit obtained an average of 85.4% and 88.8%. The effectiveness test of learning motivation shows an n-gain of 0.49 and 0.50, respectively, in the medium category. This shows that the e-module developed is very feasible and useful as a learning tool and effectively increases students' desire to learn.

Furthermore, research by Ariana et al. was assessed by material experts, subject teachers, work colleagues, and high school students, that the module could be used well in the learning process. It can be concluded that the module is suitable for use in the learning process.[7] The results of research conducted by Giawa et al. show that the feasibility of the module by material experts reached 91% of very feasible criteria, design experts achieved 94% of very feasible criteria, and the practicality results of the module based on individual trials reached 84% convenient and practical criteria.[8]

This research differs from previous research because it will use a PhET simulation, which presents images, audio, and video, making learning more interesting. Another difference is that previous research focused heavily on increasing students' motivation and creativity. In contrast, this research will focus on the results of feasibility tests for the media that will be developed in terms of design. Based on the information above, researchers are interested in conducting research titled "Development of A Discovery Learning E-Module Assisted by PhET Simulation for Sound Wave Material." Hopefully, this research can become an innovation in physics learning media, especially sound wave material. This research aims to determine the design, feasibility, and practicality of the development of an e-module based on the discovery learning assisted by PhET Simulation on sound wave material in senior high school.

METHODS

Research and development (R&D) is a type of this research. Research and development methods are used to create products and test their effectiveness.[9] Producing products that are expected to increase educational productivity, namely large numbers of graduates, quality, and relevance to needs, usually occurs in the education sector. This research uses the Alessi and Trollip learning device development model, which consists of planning, design, and development

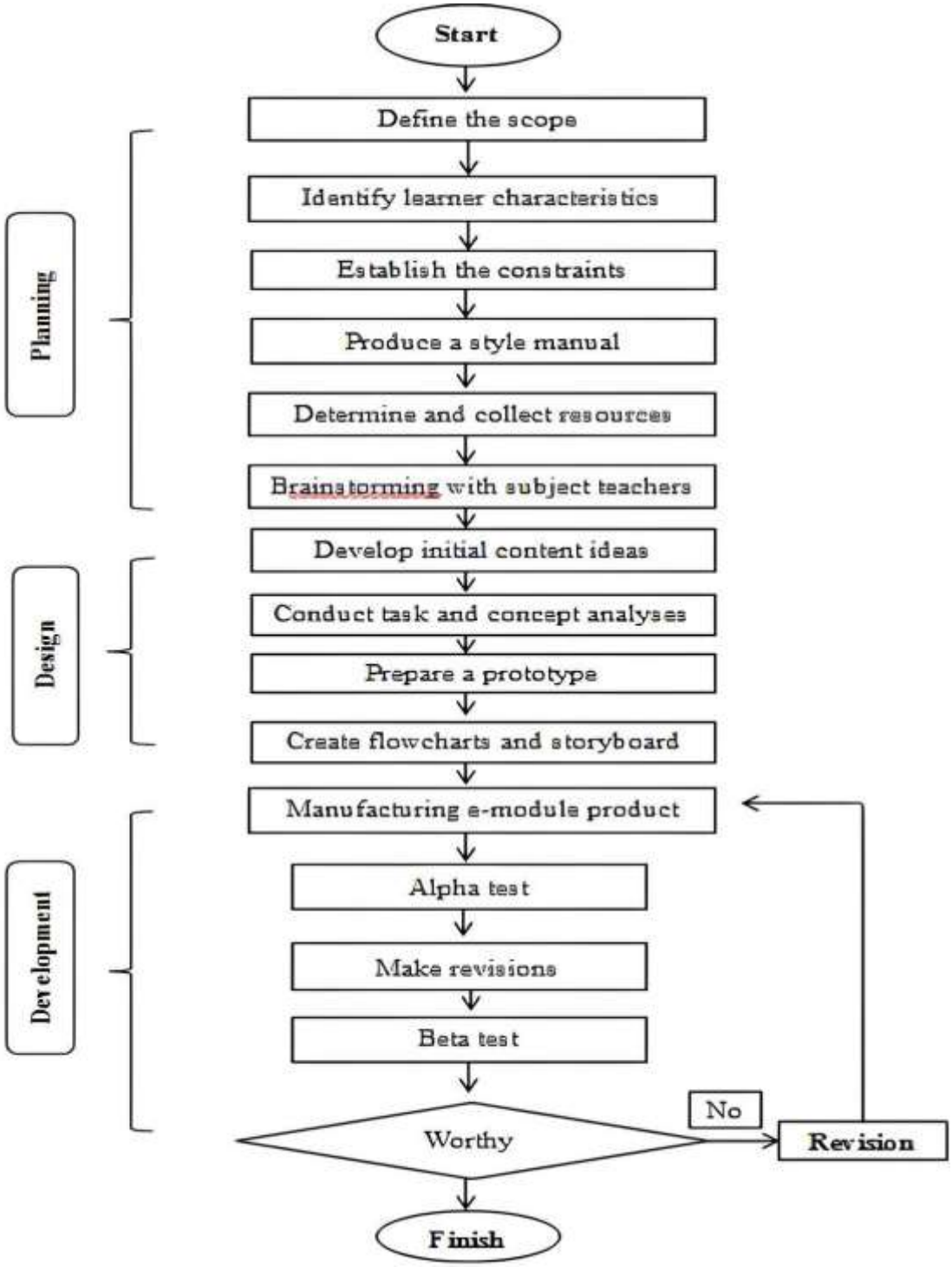
[6] Edi Ilimu Saparuddin, "Penggunaan *E-Modul* Berbasis *Discovery Learning* Melalui Pendekatan *Lesson Study* terhadap Kemampuan Kognitif Peserta Didik," *Jurnal Biotek Volume* 9, no. 1 (2021): 1–10.

[7] Desi Ariana, Risya Pramana Situmorang dan Agna Sulis Krave, "Pengembangan Modul Berbasis *Discovery Learning* Pada Materi Jaringan Tumbuhan Untuk Meningkatkan Kemampuan Literasi Sains Siswa Kelas XI IPA SMA," *Jurnal Pendidikan Matematika Dan IP*. vol 11, no. 1 (2020): 34.

[8] Relimawati Giawa, Agnes Renostini Harefa dan Toroziduhu Waruwu, "Pengembangan Modul Pembelajaran Berbasis *Discovery Learning* Pada Materi Perubahan Lingkungan," *Educativo: Jurnal Pendidikan.* vol 1, no. 2 (2022): 411–422.

[9] Sugiyono. 2019. Metode Penelitian Kuantitatif Kualitatif dan R&D. Bandung. Alfabeta. hal.753

stages in product manufacturing.[10] This model was chosen because it is suitable for developing learning tools. The flowchart of this research can be seen in Picture 1 below.



Picture 1. Research flowchart

[10] Ahmad Ahmad, Kenti Yuliana, dan M. Rizki Zulkarnain. 2019. "Pengembangan Media Belajar Berbasis Desktop Untuk Mengenal Kearifan Lokal Dan Destinasi Wisata Kalimantan Selatan," *Lentera: Jurnal Pendidikan.* vol 14, no. 1, p.13–23.

Research instruments are very important for research. The quality of the research instruments will directly influence the resulting data. Accurate and valid research results will result from good data.[11] The validation sheet given to the validator is the data collection tool used in this research. The validation sheet evaluates the feasibility of *discovery learning e-modules* assisted by PhET simulations on sound wave material in senior high school. On the validation sheet, experts are allowed to provide criticism and input on the module so that researchers can make necessary improvements or revisions to ensure that the module meets the criteria and is suitable for use in the learning process. This tool will be validated by; a) media experts, b) material experts, and c) users.

The method for collecting data or information in the field is known as data collection.[12] In this research, a questionnaire in the form of a validation sheet was used to assess the feasibility of the e-module. Using a Likert scale, the researcher gave a validation sheet to validators, including media experts, material experts, and users. Then, validators assess the e-module teaching materials by marking the checklist in the appropriate rows and columns, writing criticism and revisions if there are deficiencies in the suggestions section, or writing directly in the e-module teaching material manuscript. In this research, there are three validations, namely:

a) Media expert validation was carried out by three lecturers in Electrical Technology Education at UIN Ar-Raniry Banda Aceh to assess the suitability of learning media based on aspects of the appearance and program used.
b) Material expert validation was carried out by three lecturers from the Physics Education Study Program at UIN Ar-Raniry Banda Aceh to assess whether the sound wave learning material was suitable for use in the learning process.
c) Class XI students at MAS Darul Ulum Banda Aceh carried out user validation. The purpose of using this questionnaire was to determine the feasibility of the developed product.

This research uses quantitative and qualitative data from product development testing. Qualitative analysis from validators consists of input and criticism, while quantitative data is used to validate teaching materials and develop e-modules. Meanwhile, quantitative data is used to validate e-module development using validator assessment measures, which consist of:

Table 1. Validator Assessment Categories

Category	Mark
Strongly agree	5
Agree	4
Doubtful	3
Don't agree	2
Strongly Disagree	1

Source: Syahrum and Salim, *Quantitative Research Methodology*

This research uses the Aikens' V formula to calculate the value of the validation paper, which calculates the following content validity coefficient:

$$V = \frac{\sum s}{n\,(c-1)}$$

[11] Purwanto. 2018. *Teknik Penyusunan Instrumen Uji Validitas Dan Tealiabilitasi Untuk Penelitian Ekonomi Syariah* : *Staiapress.* hal.26

[12] Syafrida Hafni Sahir. 2022. *Metodologi Penelitian.* Yogyakarta : KBM Indonesia. hal.45

With: s = r −Io
Information:
s = refers to the difference between the score given by the rater (r) and the lowest score.
V = item validity index.
n = number of assessors.
c = highest validity number.
Io = lowest validity number.
r = score given by an assessor.

The validity criteria are shown in Table 1 below because the V value that can be obtained ranges between 0.00 and 1.00.

Table 2. Question Item Validity Level Criteria

Validation Value	Validity Level
0.80 –1.00	Very worthy
0.60 –0.80	Worthy
0.40 –0.60	Decent Enough
0.20 –0.40	Not Worth It
0.00 –0.20	Not feasible

Source: Suharsimi Arikunto, *Research Procedures*

RESULT AND DISCUSSION

1. E-Module Design

a. Planning stage

In this planning stage, the researcher carried out six steps, namely:

1) Determine the scope of the study

Researchers conducted initial observations at SMA Muhammadiyah 9 Kualuh Hulu, North Sumatra Province, to determine the needs and difficulties of class XI students regarding learning materials. They also conducted open interviews with physics teachers to learn about learning methods and problems students face during learning.

Based on the needs questionnaire analysis results, e-module learning materials and sound wave material, which are complex materials, received 26.86 percent. This is because students have the ability to learn independently with the help of e-learning modules.[13] It can be concluded that students need help understanding the concept and meaning of physics equations due to their lack of critical thinking. This is because sound waves have many similarities, which makes them difficult to understand.[14] The results of open interviews with physics teachers also confirmed that students had difficulty understanding the material. Apart from that, researchers are interested in using the discovery learning model to develop this product to increase student participation in class. This learning model encourages

[13] Kornelius Kristianto, Oktavianus Ama Ki`i dan Egidius Dewa, "Penerapan Simulasi PhET Sebagai Virtual Laboratorium Pada Materi Getaran, Gelombang Dan Bunyi Dalam Meningkatkan Pemahaman Konsep Dan Aktivitas Belajar Peserta Didik Kelas VIII SMP Negeri 3 Kupang,"*MAGNETON: Jurnal Inovasi Pembelajaran Fisika UNWIRA*, vol 1, no. 1 (2023): 37–44.

[14] Syindi Isna Maulida, Trapsilo Prihandono dan Maryani, "Pengembangan Modul Fisika Gelombang Bunyi Berbasis React Untuk Kelas XI IPA," *Jurnal Pembelajaran Fisika,* vol 8, no. 3 (2019): 174–180.

students to discover for themselves the concepts they are studying and then build an understanding of them by understanding their meaning.[15] Furthermore, this research uses PhET simulations to increase students' understanding of sound wave material.

2) Identify student characteristics

A needs questionnaire can be distributed to students to identify them. The results of the needs questionnaire and open discussions with teachers conducted by researchers showed that students only used textbooks provided by the school during physics lessons. They summarize the material they will study independently, and then the teacher explains it. In conveying physics concepts, teachers rarely use various learning media to help students understand the concepts better. On the other hand, teachers more often use textbooks to explain material. Only a few learning media can be used to convey physics concepts, and teachers usually only use textbooks without exciting audio, video, and animation content.[16]

The students' difficulty questionnaire also showed that their mistakes in choosing sound wave material were caused by their lack of understanding of the scope and details of the material, which still needed to be clarified. During learning, this material is not discussed thoroughly. The teacher only provides a general overview without doing a direct practicum. Students can only assume without understanding the material. As a result, it is hoped that the learning module, which covers sound wave material with the help of PhET simulations, will really help students understand the concepts and equations contained in the material.

3) Set constraints

This research faces obstacles because they will need many applications and software to create learning modules. PhET Simulation is used as an online simulation to replace physical practicum. One way is to enter the title of the desired practicum and log in with the researcher's email address. Researchers also use the CapCut application to edit their videos. Additionally, products can be transferred from PDF format to electronic media via Flip PDF Corporate Edition.[17] Due to its limited features, PhET Simulation is not suitable for sound wave materials. This research only uses a computer or laptop, LCD projector, and speakers. Further, an unstable network then hampered the development of this e-module.

4) Create manual styles

Researchers carefully consider grammar to make texts easier for readers to understand.[18] This includes using non-confusing punctuation, appropriate capital letters at the beginning of sentences, standard words, and visual and sound elements to increase the appeal of the text.

[15] Zaenol Fajri, "Model Pembelajaran Discovery Learning Dalam Meningkatkan Prestasi Belajar Siswa SD," *Jurnal IKA PGSD (Ikatan Alumni PGSD) UNARS* 7, no. 2 (2019): 1.

[16] Hilda Mazlina dan Fera Annisa, "Penggunaan Multimedia Interaktif Pada Pembelajaran Konsep Fluida di Kelas XI MAN Banda Aceh". *Jurnal Phi: Jurnal Pendidikan Fisika dan Fisika Terapan,* ISSN: 2460-4348 (2018), hal :13.

[17] Erina Dwi Susanti dan Ummu Sholihah, "Pengembangan E-Modul Berbasis Flip Pdf Corporate Pada Materi Luas Dan Volume Bola," *RANGE: Jurnal Pendidikan Matematika,* vol 3, no. 1 (2021): 37–46.

[18] Fikran Fadli, "Analisis Penggunaan Tanda Baca Dan Hurup Kapital Dalam Karya Surat Siswa," *Jurnal Ilmiah Mandala Education,* vol 7, no. 2 (2021): 2019–2022.

5) Determine and collect sources

In this step, the researcher collects all sources and materials relevant to the topic needed during the development process, including books related to learning material.

6) Brainstorming with subject teachers

Brainstorming sessions with subject teachers were carried out to find solutions to problems by utilizing the results of questionnaires and open interviews with teachers. This interaction resulted in the development of teaching materials that can increase students' understanding of the concept of sound waves. With the help of PhET Simulation, the resulting solution was the creation of learning e-modules based on discovery learning.

b. Design stage

At this stage, the researcher carried out four steps in the Alessi and Trollip stages, namely:

1) Developing ideas

Developing ideas is the first stage in the design process. At this point, researchers began creating learning e-modules by converting text into sentences using Microsoft Word. Next, they added images downloaded from the Pngtree website to improve the appearance of the header and footer. Creating a learning e-module includes various components, including creating an initial display of the e-module by making an example video about organ pipes and sound waves. PhET Simulation is used as a substitute for actual practice for the student worksheet section. Researchers use the Flip PDF Corporate Edition application to create electronic learning media. This allows them to include videos and make the e-modules more engaging.

2) Perform Task and Concept Analysis

Task analysis is an activity that divides various tasks or activities into small steps and then teaches them to students.[19] By creating a concept map, this task analysis step aims to organize the material systematically. Therefore, the e-module learning material becomes more accessible for students to understand. In addition, concept analysis shows that the main focus is on preparing and managing information contained in learning e-modules.

3) Preparing a prototype

This prototype aims to facilitate the product development process for researchers. At this stage, researchers design products based on previous idea analysis. This process includes creating product styles or designs manually and generating ideas with subject teachers. All these efforts aim to produce products that meet customer needs.

4) Create flowcharts and storyboards

A flowchart is a diagram or visual representation that shows the steps in a programming process and explains in detail how the program process is carried out. Flowcharts are used to provide an overview of the sequence of programs created from one stage to another so that the workflow can be easily understood by everyone. They also aim to simplify the series of

[19] Yessy Muthia, Quratul Aini dan Mega Iswari, "Efektivitas Analisis Tugas Dalam Meningkatkan Keterampilan Membuat Kerupuk Ikan Bagi Anak Tunagrahita Ringan," *Jurnal Penelitian Pendidikan Khusus,* vol 7, no. 1 (2019) : 160–165.

procedures so that the information presented is easier to understand.[20] Meanwhile, a storyboard is a general sketch of an application arranged sequentially, with explanations and specifications for each image, screen, and text.

c. Development Stage

1) Prepare text

Creating text requires the use of word processing tools. One such tool is Microsoft Word, software specifically designed for word processing. The Microsoft Word application, including Microsoft Office, is still very popular today because of its various functions, such as text processing, changing numbers, creating paragraphs, and printing documents.[21]

2) Write code

Various types of learning media, such as visual, audio, and print, can be used to make text easier to understand and attract attention.[22] At this stage, various fonts, animations, images, videos, and colors are used.

3) Generate graphs

PhET media simulation helps students understand physics concepts visually in this research stage. It allows them to create accurate and attractive graphics without needing to do so manually.[23]

4) Produce audio and video

At this stage, researchers used the CapCut application to create audio and video material. They also used programs such as PhET Simulation and YouTube as audio and video sources for the learning process. The presence of videos in learning materials can improve students' understanding through visual presentations that can be played. Videos also really help educators convey material that is complex and difficult for students to understand.[24]

5) Combining parts

The elements produced are combined, namely text, images, audio, and video, to form an e-module. The discovery learning-based e-module designed with the help of PhET simulation is used for sound waves materials in senior high school learning.

2. E-Module Eligibility

Figures 2 and 3 show the alpha test results from 6 validators, consisting of 3 media experts and 3 material experts. Media experts assessed the feasibility of the discovery learning-based e-module using PhET Simulation, which can be found in picture 2 below.

[20] Gabriella Alicia dan Evelyn Vania, *"Praktek Pemrograman C++ dan Python",* Semarang: SCU Knowledge Media, (2020) : 7-8.

[21] Dewi Irmawati, dkk, "Optimalisasi Penggunaan Microsoft Office Pada Staff Paud A. Rachman," *Snaptekmas* 1 (2019): 137–140.

[22] Pari Purnaningsih, "Strategi Pemanfaatan Media Audio Visual Untuk Peningkatan Hasil Belajar Bahasa Inggris," *Jurnal Informatika Universitas Pamulang* vol 2, no. 1 (2017): 34.

[23] Dedi Riyan Rizaldi, A. Wahab Jufri dan Jamaluddin Jamaluddin, "PhET: Simulasi Interaktif Dalam Proses Pembelajaran Fisika," *Jurnal Ilmiah Profesi Pendidikan,* vol 5, no. 1 (2020) : 10–14.

[24] Lina Novita, Elly Sukmanasa, dan Mahesa Yudistira Pratama, "Penggunaan Media Pembelajaran Video Terhadap Hasil Belajar Siswa SD". *Indonesian Journal of Primary Education,* Vol. 3, No. 2 (2019) : 67.

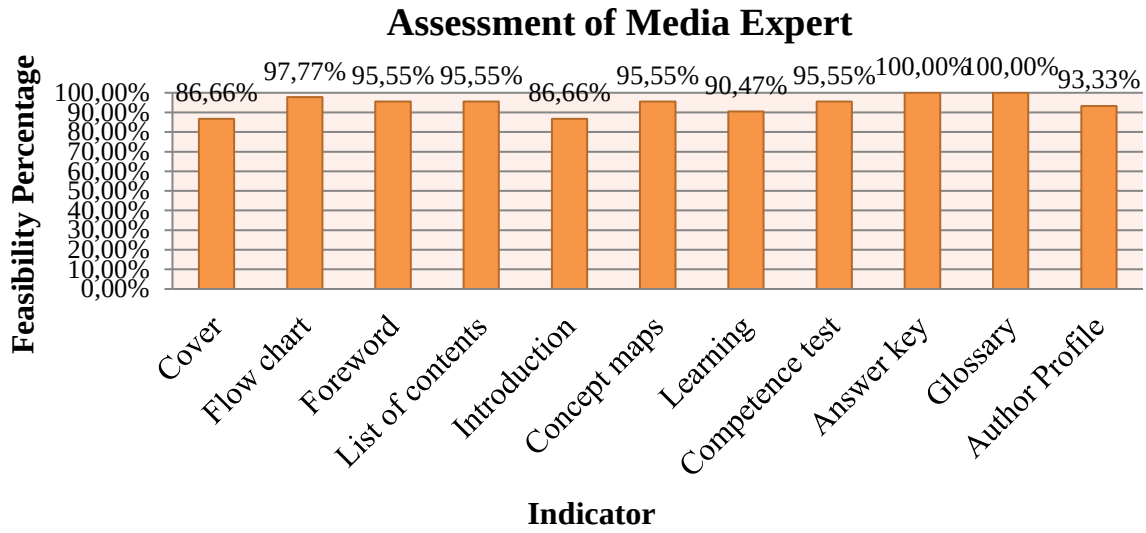


Figure 2. Media Expert Validation Results

Based on the feasibility testing in the material category validated by the wave material expert lecturer, this can be seen in Figure 3 below.

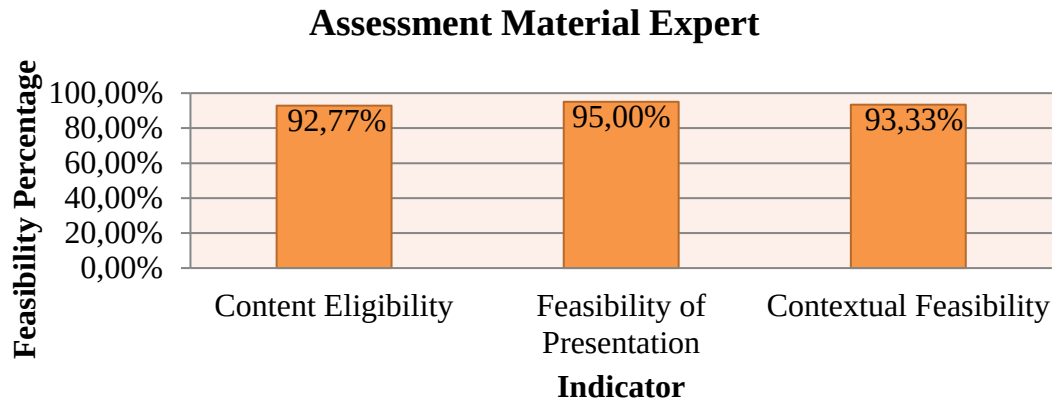


Figure 3. Material Expert Validation Results

The e-module based on discovery learning assisted by PhET Simulation on sound wave material based on Aikens' V formula obtained from media experts gave a V value of 0.92 Very worthy, and material experts obtained a V value of 0.93 Very worthy. These results support students' conceptual understanding and performance as a whole and will make it easier for educators to explain the concept of sound waves at school. The development of science learning tools using the discovery learning model on vibration and wave material has been proven valid and suitable for theoretical use, with high validity values for teaching materials and student worksheets.[25] The use of PhET SW Virtual Lab can improve student learning outcomes and

[25] Fatmawati Linggile, Supartin dan Citron S. Payu, "The Effect of Discovery Learning Based on Blended Learning on Student Learning Outcomes at SMA Negeri 1 Boliyohuto". *Jurnal Pendidikan Fisika dan Teknologi*, Vol. 8, No. 2 (2022): 293-298.

teacher skills in the learning process in each cycle.[26] Thus, E-Modules with a very feasible category will affect the results and interest of students in physics learning.

Interactive computer simulations play an essential role in enhancing students' learning experiences and promoting a deeper understanding of complex physics topics[27,28], ultimately contributing to improved educational outcomes in the field of physics education. Collectively, it shows that the integration of PhET simulations with discovery learning models is not only feasible but also highly effective in improving students' understanding of physics concepts[29], showing a positive impact on the learning process.[30] The feasibility of media in physics learning plays a vital role in improving learners' understanding. Where educators should enrich the provision of activities in PhET simulation so that learners will learn physics happily.

3. Practicality of E-Modules

Based on the Beta test validated to users consisting of educators and students who have learned sound wave material, the product of discovery learning-based e-modules assisted by PhET simulation can be seen in Table 3 below.

Table 3. Ratings by Users

Evaluation	**V**	**Category**
Product Eligibility	0.92	Very worthy
Readability and Comprehensibility	0.90	Very worthy
Engagement and Motivation	0.94	Very worthy
Conformity to Curriculum Standards	0.95	Very worthy
The average of all scores	0.93	Very worthy

Based on data analysis of validation results through distributing questionnaires, the product feasibility aspect with a score of 0.92 is in the very feasible category, the readability and understandability assessment aspect with a score of 0.90 in the very feasible category, the involvement and motivation assessment aspect with a score of 0.94 in the very feasible category and the conformity with curriculum standards with a score of 0.95 in the very decent category. Therefore, the learning e-module based on discovery learning with the help of PhET Simulation on sound wave material received an average score of 0.93 in the category of being very suitable for use in the learning process.

Validation testing to users of the PhET-assisted discoveri learning E-module in physics learning is essential to ensure its effectiveness and usability. By analyzing user responses and behavior, developers can identify areas for improvement, optimize product performance, and

[26] A Halim, Farhan, A Ahyuni, Susanna, W Andriani, and Irwandi, "The Impact Of Phet Virtual Lab Worksheets On Student Learning Outcomes On Sound Wave Materials". *Journal of Physics: Conference Series*, 1806 (2021) 012033.

[27] Gerard Tuyizere and Lakhan Lal Yadav, "Effect of interactive computer simulations on academic performance and learning motivation of Rwandan students in Atomic Physics", *International Journal of Evaluation and Research in Education,* Vol. 12, No. 1, (2023): 252-259.

[28] Amer G. Amin, Mariana Levin and Olivia Levrini, "Theorizing Concept Learning in Physics Education Research: Progress and Prospects " AIP Publishing . 2023.

[29] Almadrones, R. D.G., and Tadifa, F. G, "Physics Educational Technology (Phet) Simulations in Teaching General Physics 1", *International Journal Of Instruction*, Vol. 17, No. 3, (2024): 635-650.

[30] Ananias N. Yunzal, Jr, and Leomarich F. Casinillo, "Effect of Physics Education Technology (PhET) Simulations: Evidence from STEM Students' Performance", *Journal of Educational Research and Evaluation*, Vol. 4, No, 3,(2020): 221-226

ultimately create a more user-centric and successful product that aligns with user preferences and requirements. Evaluating the usability of digital products by assessing various factors such as learnability, efficiency, memory, errors, and satisfaction, ensures that the product meets the needs and expectations of the target users[31,32,33]. Studies emphasize the importance of user testing in educational applications, such as adaptive learning media, AR treasure hunt learning games, traffic simulators, and educational games such as Bana games, to evaluate aspects such as engagement, usability, and learning impact[34,35,36,37,38]. Usability testing methods, including the use of data mining tools, surveys, interviews, and observations, help gather feedback from users to improve the design and implementation of learning media products. By conducting user testing, developers can assess the product's learnability, efficiency, memorability, errors, and satisfaction, ensuring that the product meets the needs and expectations of target users.

CONCLUSION

The results showed that the e-module based on discovery learning assisted by PhET Simulation on sound wave material can be used as a virtual practicum for students in the teaching and learning process. Based on the alpha test of media and material experts with a very feasible category of 94.09% and based on the beta test getting a value of 93.92% very feasible category. So, e-modules based on discovery learning assisted by PhET Simulation can be used as physics learning materials on sound wave material, this e-module product can accelerate and clarify abstract theories on sound wave material for students' understanding. The study refers to one material in physics lessons at school, the object of research is still lacking, in the future it can expand the study on other physics materials and expand or increase data for beta testing by manipulating other research variables.

[31] Green, T and Labrecque, J, "User Testing. In: A Guide to UX Design and Development. Design Thinking", Apress, Berkeley, CA. (2023

[32] R. Firdaus, N. K. Hikmawati, Y. Durachman, H. Nanang, D. Khairani and M. S. Hazimi, "Usability Testing Analysis of a Company Website in Indonesia," *2022 Seventh International Conference on Informatics and Computing (ICIC)*, Denpasar, Bali, Indonesia, (2022): 1-6.

[33] Deni Kurniawan and Ferida Yuamita, "Usability Testing Penggunaan Menu Kartu Hasil Studi Di Website Sistem Informasi Akademik Universitas Teknologi Yogyakarta", Vol. 2, No.1, (2023): 41–52.

[34] Hernawan Sulistyanto, Sofyan Anif, Sutama, Sabar Narimo, Anam Sutopo, Muhammad Izzul Haq and Gamal Abdul Nasir, "Education Application Testing Perspective to Empower Students' Higher Order Thinking Skills Related to The Concept of Adaptive Learning Media", *Indonesian Journal on Learning and Advanced Education*, Vol. 4, No. 3, (2022): 257-271.

[35] Samuel Taylor and Adam Stone, "Ready, set…? End-user Testing of an AR Treasure Hunt Learning Game", JALTCALL Conference, (2022)-04.

[36] I Made Ari Saputra, I Putu Agung Bayupati, and Ni Kadek Dwi Rusjayanthi, "Usability Testing pada Simulator Media Pembelajaran Lalu Lintas Berbasis Android", *Jurnal Teknologi Informasi dan Ilmu Komputer*, Vol. 8, No. 2(2021): 265-274.

[37] F. Adnan, B. Prasetyo and Nuriman, "Usability Testing Analysis On The Bana Game As Education Game Design References On Junior High School", *Jurnal Pendidikan IPA Indonesia*, Vol. 6, No. 1, (2017): 88-94.

[38] Vikram Koundinya, Jenna Klink and Melissa Widhalm, "UserTesting.com: A Tool for Usability Testing of Online Resources", *Extension Journal*, Vol. 55, No. 3, (2017): 8.

REFERENCE

Suari, Bagus Andika, and I Gede Astawan. 2021. "Efektivitas Model Discovery Learning Terhadap Hasil Belajar IPA". *Jurnal Penelitian Dan Pengembangan Pendidikan* 5 (2):270-77. https://doi.org/10.23887/jppp.v5i2.36980.

Laeni, Sujatul, Zulkarnaen Zulkarnaen, and Shelly Efwinda. 2022. "Model Discovery Learning Terhadap Kemampuan Berpikir Kritis Siswa SMA Negeri 13 Samarinda Materi Impuls Dan Momentum". *Jurnal Literasi Pendidikan Fisika (JLPF)* 3 (2), 105-15. https://doi.org/10.30872/jlpf.v3i2.935.

Putri, Meliani, Noviandra Azzahra, Wangi Dema Lestari, and Arini. 2024. "Implementasi Inovasi Pembelajaran Berbasis Discovery Learning Melalui Pemanfaatan Media Pembelajaran Secara Efektif Di SDN Bojong Kiharib". *Karimah Tauhid* 3 (3):3449-57. https://doi.org/10.30997/karimahtauhid.v3i3.12570.

Syarifah Rahmiza Muzana, Silvi Puspa Widya Lubis, dan Wirda, "Penggunaan *Simulasi PhET* Terhadap Efektivitas Belajar IPA," *Jurnal Dedikasi Pendidikan*. vol 5, no. 1 (2021): 227–236.

Asnita Asnita dan Erizal Gani, "Pengaruh Penggunaan Model *Discovery Learning* Terhadap Keterampilan Menulis Teks Eksplanasi Siswa Kelas Viii Smp Negeri 20 Padang," *Pendidikan Bahasa Indonesi.* vol 9, no. 1 (2020): 23.

Edi Ilimu Saparuddin, "Penggunaan *E-Modul* Berbasis *Discovery Learning* Melalui Pendekatan *Lesson Study* terhadap Kemampuan Kognitif Peserta Didik," *Jurnal Biotek Volume* 9, no. 1 (2021): 1–10.

Desi Ariana, Risya Pramana Situmorang dan Agna Sulis Krave, "Pengembangan Modul Berbasis *Discovery Learning* Pada Materi Jaringan Tumbuhan Untuk Meningkatkan Kemampuan Literasi Sains Siswa Kelas XI IPA SMA," *Jurnal Pendidikan Matematika Dan IP*. vol 11, no. 1 (2020): 34.

Relimawati Giawa, Agnes Renostini Harefa dan Toroziduhu Waruwu, "Pengembangan Modul Pembelajaran Berbasis *Discovery Learning* Pada Materi Perubahan Lingkungan," *Educativo: Jurnal Pendidikan.* vol 1, no. 2 (2022): 411–422.

Sugiyono. 2019. Metode Penelitian Kuantitatif Kualitatif dan R&D. Bandung. Alfabeta. hal.753

Ahmad Ahmad, Kenti Yuliana, dan M. Rizki Zulkarnain. 2019. "Pengembangan Media Belajar Berbasis Desktop Untuk Mengenal Kearifan Lokal Dan Destinasi Wisata Kalimantan Selatan," *Lentera: Jurnal Pendidikan.* vol 14, no. 1 hal.13–23.

Purwanto. 2018. *Teknik Penyusunan Instrumen Uji Validitas Dan Tealiabilitasi Untuk Penelitian Ekonomi Syariah* : *Staiapress*. hal.26

Syafrida Hafni Sahir. 2022. *Metodologi Penelitian.* Yogyakarta : KBM Indonesia. hal.45

Kornelius Kristianto, Oktavianus Ama Ki`i dan Egidius Dewa, "Penerapan Simulasi PhET Sebagai Virtual Laboratorium Pada Materi Getaran, Gelombang Dan Bunyi Dalam Meningkatkan Pemahaman Konsep Dan Aktivitas Belajar Peserta Didik Kelas VIII SMP Negeri 3 Kupang,"*MAGNETON: Jurnal Inovasi Pembelajaran Fisika UNWIRA,* vol 1, no. 1 (2023): 37–44.

Syindi Isna Maulida, Trapsilo Prihandono dan Maryani, "Pengembangan Modul Fisika Gelombang Bunyi Berbasis React Untuk Kelas XI IPA," *Jurnal Pembelajaran Fisika,* vol 8, no. 3 (2019): 174–180.

Zaenol Fajri, "Model Pembelajaran Discovery Learning Dalam Meningkatkan Prestasi Belajar Siswa SD," *Jurnal IKA PGSD (Ikatan Alumni PGSD) UNARS* 7, no. 2 (2019): 1.

Hilda Mazlina dan Fera Annisa, "Penggunaan Multimedia Interaktif Pada Pembelajaran Konsep Fluida di Kelas XI MAN Banda Aceh". *Jurnal Phi: Jurnal Pendidikan Fisika dan Fisika Terapan*, ISSN: 2460-4348 (2018), hal :13.

Erina Dwi Susanti dan Ummu Sholihah, "Pengembangan E-Modul Berbasis Flip Pdf Corporate Pada Materi Luas Dan Volume Bola," *RANGE: Jurnal Pendidikan Matematika,* vol 3, no. 1 (2021): 37–46.

Fikran Fadli, "Analisis Penggunaan Tanda Baca Dan Hurup Kapital Dalam Karya Surat Siswa," *Jurnal Ilmiah Mandala Education,* vol 7, no. 2 (2021): 2019–2022.

Yessy Muthia, Quratul Aini dan Mega Iswari, "Efektivitas Analisis Tugas Dalam Meningkatkan Keterampilan Membuat Kerupuk Ikan Bagi Anak Tunagrahita Ringan," *Jurnal Penelitian Pendidikan Khusus,* vol 7, no. 1 (2019) : 160–165.

Gabriella Alicia dan Evelyn Vania, *"Praktek Pemrograman C++ dan Python"*, Semarang: SCU Knowledge Media, (2020) : 7-8.

Dewi Irmawati, dkk, "Optimalisasi Penggunaan Microsoft Office Pada Staff Paud A. Rachman," *Snaptekmas* 1 (2019): 137–140.

Pari Purnaningsih, "Strategi Pemanfaatan Media Audio Visual Untuk Peningkatan Hasil Belajar Bahasa Inggris," *Jurnal Informatika Universitas Pamulang* vol 2, no. 1 (2017): 34.

Dedi Riyan Rizaldi, A. Wahab Jufri dan Jamaluddin Jamaluddin, "PhET: Simulasi Interaktif Dalam Proses Pembelajaran Fisika," *Jurnal Ilmiah Profesi Pendidikan,* vol 5, no. 1 (2020) : 10–14.

Lina Novita, Elly Sukmanasa, dan Mahesa Yudistira Pratama, "Penggunaan Media Pembelajaran Video Terhadap Hasil Belajar Siswa SD". *Indonesian Journal of Primary Education,* Vol. 3, No. 2 (2019) : 67.

Fatmawati Linggile, Supartin dan Citron S. Payu, "The Effect of Discovery Learning Based on Blended Learning on Student Learning Outcomes at SMA Negeri 1 Boliyohuto". *Jurnal Pendidikan Fisika dan Teknologi*, Vol. 8, No. 2 (2022): 293-298.

A Halim, Farhan, A Ahyuni, Susanna, W Andriani, and Irwandi, "The Impact Of Phet Virtual Lab Worksheets On Student Learning Outcomes On Sound Wave Materials". *Journal of Physics: Conference Series*, 1806 (2021) 012033.

Gerard Tuyizere and Lakhan Lal Yadav, "Effect of interactive computer simulations on academic performance and learning motivation of Rwandan students in Atomic Physics", *International Journal of Evaluation and Research in Education*, Vol. 12, No. 1, (2023): 252-259.

Amer G. Amin, Mariana Levin and Olivia Levrini, "Theorizing Concept Learning in Physics Education Research: Progress and Prospects " AIP Publishing . 2023.

Almadrones, R. D.G., and Tadifa, F. G, "Physics Educational Technology (Phet) Simulations in Teaching General Physics 1", *International Journal Of Instruction*, Vol. 17, No. 3, (2024): 635-650.

Ananias N. Yunzal, Jr, and Leomarich F. Casinillo, "Effect of Physics Education Technology (PhET) Simulations: Evidence from STEM Students' Performance", *Journal of Educational Research and Evaluation*, Vol. 4, No, 3,(2020): 221-226

Green, T and Labrecque, J, "User Testing. In: A Guide to UX Design and Development. Design Thinking", Apress, Berkeley, CA. (2023

R. Firdaus, N. K. Hikmawati, Y. Durachman, H. Nanang, D. Khairani and M. S. Hazimi, "Usability Testing Analysis of a Company Website in Indonesia," *2022 Seventh International Conference on Informatics and Computing (ICIC)*, Denpasar, Bali, Indonesia, (2022): 1-6.

Deni Kurniawan and Ferida Yuamita, "Usability Testing Penggunaan Menu Kartu Hasil Studi Di Website Sistem Informasi Akademik Universitas Teknologi Yogyakarta", Vol. 2, No.1, (2023): 41–52.

Hernawan Sulistyanto, Sofyan Anif, Sutama, Sabar Narimo, Anam Sutopo, Muhammad Izzul Haq and Gamal Abdul Nasir, "Education Application Testing Perspective to Empower Students' Higher Order Thinking Skills Related to The Concept of Adaptive Learning Media", *Indonesian Journal on Learning and Advanced Education*, Vol. 4, No. 3, (2022): 257-271.

Samuel Taylor and Adam Stone, "Ready, set…? End-user Testing of an AR Treasure Hunt Learning Game", JALTCALL Conference, (2022)-04.

I Made Ari Saputra, I Putu Agung Bayupati, and Ni Kadek Dwi Rusjayanthi, "Usability Testing pada Simulator Media Pembelajaran Lalu Lintas Berbasis Android", *Jurnal Teknologi Informasi dan Ilmu Komputer*, Vol. 8, No. 2(2021): 265-274.

F. Adnan, B. Prasetyo and Nuriman, "Usability Testing Analysis On The Bana Game As Education Game Design References On Junior High School", *Jurnal Pendidikan IPA Indonesia*, Vol. 6, No. 1, (2017): 88-94.

Vikram Koundinya, Jenna Klink and Melissa Widhalm, "UserTesting.com: A Tool for Usability Testing of Online Resources", *Extension Journal*, Vol. 55, No. 3, (2017): 8.