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Interactive E-Modules as Teaching Materials on Diffraction and Interference Materials: A Feasibility Test

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ABSTRACT

The selection of learning teaching materials must be carried out as needed and can also utilize technology as a means of making interesting teaching materials. One of the learning teaching materials that can be used to easily understand the concepts of diffraction and interference and utilize technology is an interactive e-module equipped with learning videos. This is because learning about diffraction material and interference with physics requires visualization to improve students' understanding of the material. The research method used is Research and Development or R&D (Research and Development) with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model. Research and development of education (research and development) aims to produce new products through the development process. In this study, there was a limitation of steps from five steps to four steps to due diligence according to development needs. The results showed that the interactive e-module on the diffraction and interference material made by the researcher was suitable for use.

INTISARI

Pemilihan bahan ajar pembelajaran harus dilakukan sesuai kebutuhan dan juga dapat memanfaatkan teknologi sebagai sarana pembuatan bahan ajar yang menarik. Salah satu bahan ajar pembelajaran yang dapat digunakan agar mudah memahami konsep difraksi dan interferensi serta memanfaatkan teknologi yaitu dengan e-modul interaktif yang dilengkapi dengan video pembelajaran. Hal ini dikarenakan pembelajaran pada materi difraksi dan interferensi pada fisika membutuhkan visualisasi untuk meningkatkan pemahaman siswa terkait materi. Metode penelitian yang digunakan adalah *Research and Development* atau R&D (Penelitian dan Pengembangan) dengan model ADDIE (*Analysis, Design, Development, Implementation, Evaluation*). Penelitian dan pengembangan pendidikan (*research and development*) bertujuan untuk menghasilkan produk baru melalui proses pengembangan. Dalam penelitian ini terdapat pembatasan langkah-langkah dari lima langkah menjadi empat langkah sampai uji kelayakan sesuai kebutuhan pengembangan. Hasil penelitian menunjukan bahwa e-modul interaktif pada materi difraksi dan interferensi yang dibuat peneliti layak digunakan.

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KEYWORDS
E-modul, Interaktif, Bahan Ajar, Difraksi, Interferensi

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A. Introduction

The development of science supports the creation of technological advances that mark the era of globalization. In short, current technological advances have really been recognized and felt to provide a lot of convenience and comfort for human life [1]. In the era of globalization, developing technology has entered the digital stage in every field, including in the field of education. Education in various parts of the world uses technology to support the implementation of learning. Technology is the result of the development of science, which means that it comes from the world of education. Thus, education should also use technology to support the implementation of learning. This is in accordance with the opinion of Tondelur et al (in Selwyn) [2] which states that digital technology has now begun to be used in educational institutions as a means to support learning, either as an information tool (i.e. as a means of accessing information) or as a learning tool (i.e. as a means of supporting learning activities and assignments). One of them is technology that can be used in the manufacture of teaching materials.

The use of technology in the world of education is used as a means of making teaching materials that are increasingly interesting/creative. In line with the research conducted [3] explained that teaching materials are an important part in determining the quality of learning. The teaching materials used will determine the achievement of each defined basic competency. Teaching materials that meet good criteria will give birth to an effective learning process [4]. On the other hand, if the teaching materials do not meet the criteria, various problems in learning will emerge.

The definition of teaching materials according to Hall [5] is all forms of materials used to assist teachers or instructors in carrying out the teaching and learning process. Meanwhile, according to Sudjana [6] The learning process is an activity to implement the curriculum of an educational institution, in order to influence students to achieve the educational goals that have been set. Teaching materials are all materials (both information, tools, and texts) that are systematically arranged, which displays a complete figure of competencies that will be mastered by students and used in the learning process with the aim of planning and reviewing learning implementation [7].

The teaching and learning process adopted in the 2013 Curriculum is as stated in the National Education System Law no. 20 of 2003 article 1 states that "The learning process is student-centered, where students are required to actively seek solutions to problems encountered related to the learning process" [8]. This means the selection of teaching materials must be done in accordance with the needs so that the quality of education is increasing so that learning objectives can be achieved. However, science learning in high school is still passive due to the limitations of the teaching materials used, including in physics learning physical optics.

Physics is a branch of natural science that is closely related to the phenomena that occur in the natural environment. According to Chodijah et al [9] physics is a

science that studies natural phenomena, events or phenomena, and reveals all the secrets and laws of the universe. Therefore, in the physics learning process, teaching materials are needed as intermediary media such as pictures, videos, animations to visualize the material so that it is easily understood by students. Based on this, learning physics cannot be separated from mastering concepts, applying them in solving physics problems, and working scientifically. However, physics learning in today's classrooms tends to emphasize mastery of concepts and override students' physics problem solving abilities [10].

One of the teaching materials that can be used in the physics learning process is e-module. E-module or electronic module is a module in digital form, which consists of text, images, or both containing digital electronics material accompanied by simulations that can and are suitable for use in learning [11]. The module is one of the teaching materials that has the characteristics of the principle of independent learning. Independent learning according to Oka [12] is a way of active learning and participation to develop each individual self that is not tied to the presence of teachers, lecturers, face-to-face meetings in class, the presence of school friends. It is also supported by the rapid development of technology. Most students, especially high school students, are familiar with currently developing information technology such as computers or other electronic media.

Based on research conducted by Suryadie [13], electronic modules are innovative media that can increase student interest in learning. Improved learning outcomes can be realized with the support of appropriate learning guidelines in the teaching and learning process. So that there is an innovation in teaching materials in the form of interactive e-modules that it can be equipped with animated images or videos that can visualize physical optics material.

B. Method

This research uses part of Research and Development or R&D (Research and Development). This method is a research method used to produce certain products and test the effectiveness of these products. This research is not to test the effectiveness of certain products but only to test the feasibility of certain products. Research and development of education (research and development) aims to produce new products through the development process. The research product that we will produce is in the form of an interactive learning e-module. The development procedure carried out in this study is part of the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) developed by Dick and Carry (1996) in Mulyatiningsih [14].

1. Analysis

The analysis phase of this researcher was carried out by analyzing the teaching materials and media used in learning. At this stage the researchers also made observations on teaching and learning activities carried out in the classroom on physical optics subjects. This observation activity has the aim of knowing the obstacles that occur when the lesson is carried out, the material presented, and the media used.

2. Design

At this stage the researcher determines the elements that will be included and developed into the learning media. Researchers create a concept map that forms the basis of media content in general, which includes the design of templates and materials that fill the media. The manufacture of these products is guided by the design and concept maps that have been made.

3. Development

This stage is the creation of interactive learning e-modules. Researchers create media according to concept maps and designs that have been made with the Canva application for e-modules and videos using PowToon.

4. Feasibility Test

The media that has been developed is then tested for feasibility to physics education students of UNY 2020 by filling out a questionnaire made with a google form. Questions contained in the google form include (1) Design cover and content display of the interactive learning e-module, (2) Clarity and suitability of images presented in the interactive learning e-module, (3) Suitability of interactive learning e-modules to improve student understanding, (4) Suitability, completeness and collapse of physical optical materials presented in interactive learning e-modules, (5) Conformity of images with the content of the material presented in the interactive learning e-module, (6) Effectiveness of delivery of physical optics material in the form of interactive learning e-modules to help improve student understanding, (7) Suitability of the use of words and sentences in interactive learning e-modules with PUEBI rules, (8) Feasibility of using interactive learning e-modules as learning materials independently, (9) Overall video design, (10) The suitability of the content of the material on the video with the content of the material on the interactive learning e-module, and there are also criticisms and suggestions in the last item. The questionnaire has 10 questions that include aspects of appearance, aspects of content, aspects of language, aspects of interactivity, and aspects of media as in table 1.

Table 1. Media Feasibility Aspects

Aspect	Number	Total
Display Aspect	1.2	2
Content Aspect	3,4,5,6	4
Language Aspect	7	1
Interactivity Aspect	8	1
Media Aspect	9, 10	2
	Total	10

This study uses a google form questionnaire to collect data on variable X which consists of 10 questions. Researchers grouped the answers or responses from each item into 4 levels of answers based on the rating scale as shown in Table 2.

Table 2. Rating Scale

Answer	Score
Very Worthy	4
Worthy	3
Not feasible	2
Very Inappropriate	1

At the feasibility analysis stage of the learning e-module using the ideal standard deviation (SBi) with several stages as follows:

a. Calculating the average score of the assessment aspect [15]

$$\overline{X} = \frac{\sum X}{n}$$

Information:

$\overline{X}$ = average score

x = total score

n = number of raters

b. Converts scores to a 4 scale

The reference for changing the score to a scale of 4 is to calculate the ideal average (Mi) with the formula:

$$\text{Mi} = (\text{ideal max score} + \text{ideal min score})\frac{1}{2}$$

After finding the value of Mi, proceed with finding the value of SBi with the formula:

$$SBI = \frac{1}{6} \text{ (ideal max score – ideal min score)}$$

c. Determining the Assessment Criteria

The assessment criteria based on the SBI calculation can be seen in the following table

Table 3. Quantitative score range

Quantitative Score Range	Category
X Mi + 1.5 SBi	Very Worthy
Mi + 1.5 SBi X Mi	Worthy
X > M Mi – 1.5 SBi	less worthy
Mi - 1.5 Sbi > X	Not feasible

The calculation of the assessment criteria is changed in a scale range of 1-4 in the following way:

$$Mi = (4 + 1) = 2.5$$
$$SBi = (4-1) = 0.5$$

Based on these calculations, the assessment criteria for research are obtained, namely in the following table [15]:

Table 4. Quantitative score range

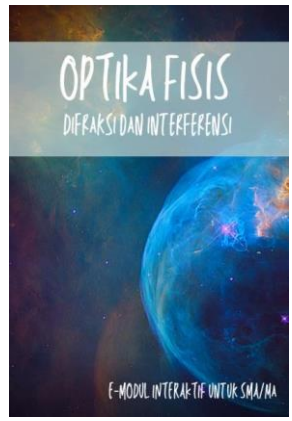
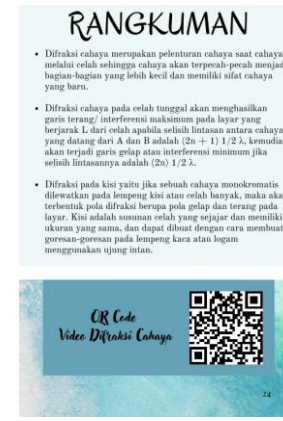
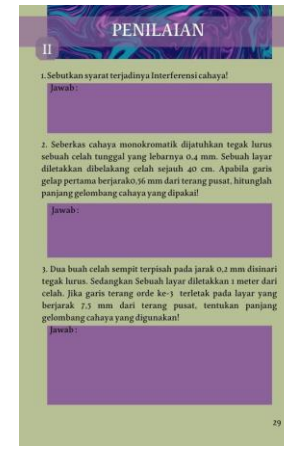
Quantitative Score Range	Category
X 3.25	Very Worthy
3.25 X 2.5	Worthy
2.5 > X 1.75	less worthy
1.75 > X	Not feasible

C. Results and Discussion

In the first stage of the initial analysis, there are obstacles in the physical optics learning process, namely the difficulty of understanding diffraction and interference materials. The learning that is carried out is less interesting and monotonous, and there is no visualization related to the material. Interactive learning teaching materials are in the form of interactive e-modules equipped with QR barcodes containing learning videos using PowToon.

In the second stage, the design stage was carried out in the form of an initial design of interactive learning e-modules, table learning, the initial design of learning media made using a module design application using Canva and video using PowToon.

Table 5. Product Design

Page	Product Design	Page	Product Design
Cover		3	
1		4	
2		Tutorial video	

In the third stage, namely the development of this research in the form of interactive teaching materials. These teaching materials are improved based on assessments in the form of suggestions and constructive criticism from students majoring in physics education as respondents. The feasibility of the interactive e-

module equipped with a QR code containing the learning video was calculated using the ideal standard deviation of the responses of physics education students as respondents on a scale of one to four. The analysis of the feasibility test for teaching materials in the form of interactive e-modules equipped with a QR code containing learning videos on diffraction material and physical optical interference shows the aspects of appearance, content, language, interactivity, and media.

The results of the analysis of the feasibility test of the interactive e-module equipped with a QR code containing learning videos on diffraction and physical optical interference materials are as follows:

Table 6. The results of the feasibility analysis of the interactive e-module equipped with a QR code containing learning videos on diffraction material and physical optical interference

Aspect	Average value	Category
Appearance	3.59	Very Worthy
Contents	3.61	Very Worthy
Language	3.64	Very Worthy
Interactivity	3.51	Very Worthy
Media	3.70	Very Worthy

The results obtained from the analysis of the feasibility test for interactive e-module teaching materials equipped with a QR code containing learning videos on diffraction and physical optics interference obtained the average value of all aspects, namely 3.62 with a very feasible category.

Interactive e-module teaching materials equipped with QR codes containing learning videos on diffraction and physical optical interference have been carried out in three stages of development, namely Analysis, Design, and Development. The work on interactive e-module teaching materials is first done by determining the basic competencies, indicators, and learning objectives and then determining the e-module concept so that it can be understood by students.

The design of e-module teaching materials is done using the Canva application for e-module editing and the PowToon application for editing learning videos which will later be obtained in the form of an interactive e-module design draft equipped with a QR code containing learning videos on diffraction material and physical optical interference. Feasibility test of interactive e-module interactive learning media equipped with a QR code containing learning videos on diffraction material and physical optical interference with data collection using a questionnaire containing aspects of appearance, content, language, interactivity, and media. All of these aspects

serve as guidelines in determining the feasibility of the interactive e-module which the researcher tested its feasibility.

In this study used data in the form of qualitative data. The study was conducted on students of Physics Education UNY academic year 2020. Researchers conducted a feasibility test through a questionnaire for 32 physics education students. The data obtained is then described with the criteria of very feasible, feasible, not feasible, and very inappropriate by choosing one of these criteria.

In the aspect of display, it has indicators, namely the first cover design and display of the contents of the interactive learning e-module, the second is the clarity and suitability of the images presented in the interactive learning e-module. The first indicator based on the respondent's assessment gets an average of 3.54 in the very feasible category. The second indicator gets an average of 3.64 with a very decent category. In the aspect of content it has indicators, first the suitability of interactive learning e-modules to improve students' understanding, both the suitability, completeness and coherence of the physical optics material presented in the interactive learning e-module, the third suitability of the image with the content of the material presented in the interactive learning e-module, the fourth the effectiveness of delivering physical optics material in the form of an interactive learning e-module to help improve participants' understanding educate. The first indicator based on the respondent's assessment got an average of 3.74 in the very feasible category. The second indicator gets an average of 3.77 with a very decent category, the third indicator gets an average of 3.58 with a very decent category, the fourth indicator gets an average of 3.35 with a very decent category. The language aspect includes the suitability of the use of words and sentences in the interactive learning e-module with the PUEBI rules. Respondents' assessment of these questions is in the very appropriate category with an average of 3.64. The Interactivity Aspect contains the feasibility of using interactive learning e-modules as independent study materials. Respondents rated the category very feasible with an average of 3.51. From this assessment, this e-module is suitable to be used as an independent study material. The media aspect has two indicators, namely the overall video design and the suitability of the video content with the content of the material in the e-module. An interactive e-module equipped with a QR code containing learning videos on diffraction and physical optics interference can increase understanding and knowledge of physical optics so as to motivate students to learn about interference and diffraction. The video in this e-module is considered very interactive so that it can instill an in-depth understanding of the concept of the material. The Media Aspect has an average of 3.70 with a very decent category.

D. Conclusion

Based on the results of analysis, design, and development, interactive learning teaching materials in the form of interactive e-modules equipped with QR codes containing learning videos on diffraction and interference are solutions that can help students understand diffraction and interference materials in physical optics. The results of the feasibility test for interactive learning e-module teaching materials equipped with QR barcodes containing learning videos on diffraction and interference materials were considered very feasible.

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References

[1] Dwiningrum, S. I. A., Basic Social Sciences & Culture (*Ilmu Sosial & Budaya Dasar)*. Yogyakarta: UNY Press, 2012.

[2] Toffler, A, The Future Shock. Translated by Hermawan Sulistyo. Jakarta: Pantja Simpati. 1992.

[3] Cahyadi, R.A.H., "ADDIE Model-Based Teaching Material Development *(Pengembangan Bahan Ajar Berbasis ADDIE Model)"*, Halaqa Islam: Jurnal Edukasi, vol. 3, pp. 35–42, 2019.

[4] Yati, W., Amini, R., "Development of Teaching Materials with a Tournament-Type Cooperative Learning Approach for Students in Grade IV Elementary School *(Pengembangan Bahan Ajar Dengan Pendekatan Cooperative Learning Tipe Turnamen Pada Siswa Di Kelas IV SD)"*, vol. 4, pp. 10, 2020.

[5] Hall, M. C., Key Aspects of Competency-based Assessment. South Australia: National Center of Education Research, 2007.

[6] Sudjana, N., Statistical Method *(Metode Statistika)*. Bandung: Tristo, 2005.

[7] Desyandri, D., "Development of Integrated Thematic Teaching Materials in Grade V Elementary Schools Using Problem Identification (Preprint) *(Pengembangan Bahan Ajar Tematik Terpadu Di Kelas V Sekolah Dasar Menggunakan Identifikasi Masalah (Preprint))"*. Ina-Rxiv, 2018.

[8] Presiden Republik Indonesia. Law of the Republic of Indonesia No. 20 Year 2003 about National Education System *(Undang-Undang Republik Indonesia nomor 20 tahun 2003 tentang Sistem Pendidikan Nasional)*, 2003.

[9] Chodijah, S., A. Fauzi., R. Wulan, "Development of Physics Learning Devices Using the Guided Inquiry Model Equipped with Portfolio Assessment on Circular Motion Material *(Pengembangan Perangkat*

Pembelajaran Fisika Menggunakan Model Guided Inquiry yang Dilengkapi Penilaian Portofolio Pada Materi Gerak Melingkar)". Jurnal Penelitian Pembelajaran Fisika, vol.1, pp.1-19, 2012.

[10] Hoellwarth, C., Moelter, M. J., & Night, R. D., "Direct Comparison of Conceptual Learning and Problem-Solving Ability in Traditional and Studio Style Classrooms", American Journal of Physics, 459, 2005.

[11] Herawati, N. S., & Muhtadi, A., "Development of interactive electronic modules (e-modules) in the subject of Chemistry class XI Senior High School *(Pengembangan modul elektronik (e-modul) interaktif pada mata pelajaran Kimia kelas XI SMA)". Jurnal inovasi teknologi pendidikan*, vol.*5*(2), pp. 180-191, 2018.

[12] Oka, A. A., "The Influence of Application of Independent Learning on Ecosystem Material on Critical Thinking Skills and Problem-Solving Ability of High School Students in Metro City *(Pengaruh Penerapan Belajar Mandiri Pada Materi Ekosistem Terhadap Keterampilan Berpikir Kritis dan Kemampuan Memecahkan Masalah Siswa SMA di Kota Metro)"*, *Bioedukasi*, vol,1(2), 2010.

[13] Suryadie, Development of a Shared Type Integrated Science Electronic Module for Class VIII Students of SMP/MTs *(Pengembangan modul elektronik IPA terpadu tipe shared untuk siswa kelas VIII SMP/MTs)*. Yogyakarta: UIN Sunan Kalijaga, 2014.

[14] Mulyatiningsih, E., Applied Research Methods in the Field of Education *(Metode Penelitian Terapan Bidang Pendidikan)*. Bandung: Alfabeta, 2012.

[15] Mardapi Djemari, Educational Assessment & Evaluation Measurement *(Pengukuran Penilaian & Evaluasi Pendidikan)*. Yogyakarta: Nuha Medika, 2012.

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Optical Games as Alternative Learning Media to Increase Students' Learning Interest in Interference and Light Diffraction Material

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ABSTRACT

The COVID-19 pandemic, which has occurred for more than two years, has affected all aspects of life, including the world of education. Along with the increasingly sloping case of the spread of the COVID-19 virus, now many schools are starting to re-implement the offline learning system. Students accustomed to learning with an online pattern must get used to returning to learning with an offline pattern. In this transitional period, of course, various problems arise, one of which is the decline in student interest in learning. This study develops one of the learning media in the form of an application game to increase student interest in learning. This study aims to determine the feasibility of game-based learning media to increase student interest in light interference and diffraction. The research method used is the research and development method with the 4D model method. The findings in this study are games can be used as an alternative learning media to increase students' interest in learning the material. Based on the stages that have been carried out, the results of the feasibility test of the Instagram comic learning media product are declared very feasible.

INTISARI

Pandemi covid-19 yang sudah terjadi lebih dari dua tahun ini telah mempengaruhi seluruh aspek kehidupan termasuk dunia pendidikan. Seiring dengan kasus penyebaran virus covid-19 yang kian melandai, kini banyak sekolah yang mulai kembali memberlakukan sistem pembelajaran secara luring. Siswa yang sudah terbiasa belajar dengan pola daring harus membiasakan diri untuk kembali melaksanakan pembelajaran dengan pola luring. Dalam masa peralihan ini tentunya muncul berbagai masalah, salah satunya adalah menurunnya minat belajar siswa. Penelitian ini mengembangkan salah satu media pembelajaran berupa game aplikasi untuk meningkatkan minat belajar siswa. Penelitian ini bertujuan untuk mengetahui tingkat kelayakan media pembelajaran berbasis game untuk meningkatkan minat belajar siswa pada materi interferensi dan difraksi cahaya. Metode penelitian yang digunakan adalah metode penelitian pengembangan (Research and Development) dengan metode 4D model. Temuan dalam penelitian ini adalah game dapat digunakan sebagai alternatif media pembelajaran untuk meningkatkan minat belajar siswa pada materi interferensi dan difraksi cahaya. Berdasarkan tahapan-tahapan yang telah dilakukan, hasil uji kelayakan produk media pembelajaran berbasis game ini dinyatakan sangat layak.

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A. Introduction

The COVID-19 pandemic, which has occurred for more than two years, has affected all aspects of life, including the world of education. Along with the increasingly sloping case of the spread of the COVID-19 virus, now many schools are starting to re-implement the offline learning system [1]. This follows the Circular Letter of the Minister of Education, Culture, Research, and Technology Number 2 of 2022 concerning Discretion in Implementing a Joint Decree of four Ministers on Guidelines for Implementation of Learning in the Covid-19 Pandemic Period, Limited Face-to-Face Learning (PTM) can be carried out with a total of 50 students. % (fifty percent) of the capacity of classrooms in educational units located in areas with Community Activity Restrictions (PPKM) level 2 (two) [2]. After almost two years of carrying out online learning, students need a re-adaptation process. Students who are used to learning with an online pattern must get used to returning to carrying out learning with an offline pattern. In this transitional period, various problems arise, and various obstacles arise such as decreased student enthusiasm for learning, less active students during classroom learning, and learning that is felt to be boring, causing a decrease in student interest in learning.

Based on research conducted by Sulistyorini [3] stated various obstacles experienced by students when the pandemic started, such as (1) The psychological condition of students who suddenly took a long vacation for fear of the impact of Covid-19, (2) Good learning resources. At first, students can borrow textbooks alternately automatically, but it can't be done, (3) The decline in students' critical thinking skills is due to adjustments from school activities to being at home, (4) The only source of learning at home is the internet, (5) Student practice facilities which are inadequate, (6) Almost all students in the class have smartphones but not all have applications that support and internet quota, (7) Students do not yet have awareness in collecting assignments given by the teacher. This was experienced by students for approximately 2 months, causing a decrease in student interest in learning. The decline in students' interest in learning after a long period of online learning requires teachers to innovate so that learning objectives can be achieved. One of the things that can be done to increase students' interest in learning is by implementing

Games is one of the alternative learning media. This is in line with research conducted by Sujalwo [4] one of the methods that can be used in game-based learning, namely the use of games as learning media. learning that includes cognitive, social, emotional, and physical development. According to Ramadhan, et al [5] , Learning games are game applications that contain educational materials or information. Some of the advantages that can be obtained by utilizing games as learning media include: (1) creating active learning because students as game players are required to complete tasks independently, (2) providing entertainment and different colors than just listening, and (3) provides direct examples of the topics studied [4].

Based on research conducted by Lutfia [6], it was found that light wave material contains the subject of light interference and diffraction which is one of the physics materials that are considered difficult for most students. Therefore, we offer a solution in the form of developing learning media in the form of application games to increase student interest in learning, especially on light interference and diffraction materials.

B. Method

This research is a type of research and development research that aims to develop the design of learning media in the form of application games to increase student interest in learning, especially on light interference and diffraction materials. The product produced in this research is a game application design called optics game. The development model that will be used in this research is the 4D model. The 4-D development method (Four-D model) is a model for developing learning tools [7]. This model consists of 4 main stages, namely define, design, develop and disseminate.

The first stage is define, the activities in this stage are initial - final analysis, student analysis, material analysis, task analysis, and specification of learning objectives. The problem that the researchers got after conducting the analysis was related to the lack of interest in student learning, especially after going through approximately 2 years of online learning. The second stage is design, the purpose of this stage is to produce a learning device design. The design of learning media that researchers want to develop is learning media in the form of optical games. This optical game contains material about physical optics that will be packaged in an interesting way.

The third stage is develop, in this stage the researcher makes designs related to learning media in the form of optical games. After making the optical design of the game, then we conducted a feasibility test to determine the level of optical feasibility of this game if it is used as an alternative learning media to increase student interest in learning, especially on light interference and diffraction materials. The method used is a survey by distributing feasibility test questionnaires to 30 respondents consisting of 30 students with the criteria of having studied light interference and diffraction materials. Filling out the questionnaire using Google Forms by ensuring that one respondent can only fill out the questionnaire once. The aspects that were tested were the media aspect, the motivation indicator aspect, the material aspect, and the design aspect. With the following assessment indicators:

Table 1. Feasibility Test Indicator

Aspect	Indicator
Material Eligibility	1. Content compatibility with interference and diffraction materials. 2. The level of ease of the material to be understood. 3. Feasibility of optical games as an alternative learning media to increase student interest in learning.
Language	1. The language used is easy to understand. 2. The language used is in accordance with PUEBI.
Media	1. Feasibility of display design. 2. Display color match.

As for this research only until the third stage of the 4D model research method, this is because the purpose of this study is only to determine the feasibility level of the game's optical design. The game optical feasibility analysis technique is used using SDi (ideal standard deviation). The assessment criteria based on the standard deviation can be seen in the table 2 below.

Table 2. Standard Deviation and Category

Quantitative score range	Category
$X \geq M\text{i} + 1,5\ SB\text{i}$	very feasible
$M\text{i} + 1,5SB\text{i} \geq X \geq M\text{i}$	feasible
$M\text{i} > X \geq M\text{i} + 1,5SB$	Not feasible
$M\text{i} + 1,5SB\text{i} > X$	Very unfeasible

The equation of the criteria above is then changed in a scale range of 1-4

$$\text{Mi} = 1/2\ (4 + 1) = 2,5$$
$$SB\text{i} = 1/2\ (4 - 1) = 0,5$$

Based on the assessment criteria for a value scale of 4, the assessment criteria for research are obtained in the tabel 3:

Table 3. Assessment Criteria and Category

Quantitative score range	Category
$X \geq 3,25$	Very feasible
$3,25 \geq X \geq 2,5$	feasible
$2,5 \geq X \geq 1,75$	Not feasible
$1,75 > X$	Very feasible

C. Results and Discussion

This study used the 4D model and limited to Development stage to determine the feasibility level of the game's optical design. The result of the learning media development in this study is a game design which was named "optics game". The physics material presented in the conversation was related to light interference and

diffraction. The following is a product design from the development of optical game learning media.

1. Media Preview

Figure 1. Media Preview of Optics Game

2. Help Page

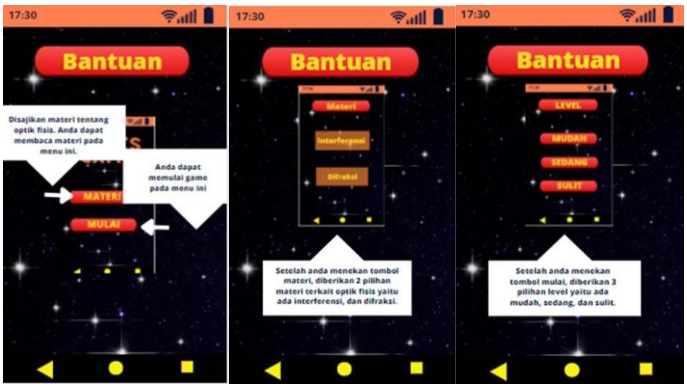


Figure 2. Help page of Optics Game

3. Material Page

Figure 3. Material Page of Optics Game

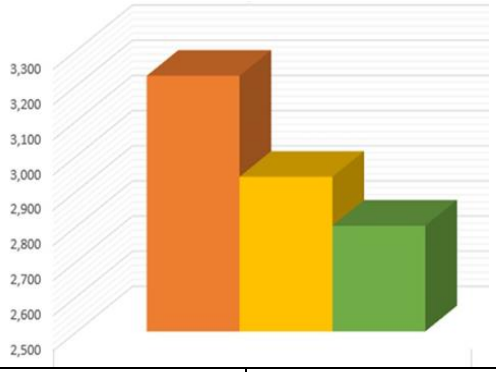
4. Physics Phenomena Page

Figure 4. Physics Phenomena of Optics Game

5. Evaluation

Figure 5. Evaluation Page of Optics Game

In this study, the feasibility of the optics game design was assessed based on the assessment of 30 respondents consisting of students with the criteria of having studied physical optical material related to light interference and diffraction. The aspects that were tested for feasibility were the media aspect, the language aspect, and the material aspect.



	media feasibility	3,227
	language feasibility	2,940
	material feasibility	2.801

Figure 6. Graph of Comparison of Feasibility Test

Based on all aspects of the assessment, the results obtained where the media feasibility aspect received the highest points of 3,227. This is because many examiners consider that the design of the optics game that we have developed is attractive so that it supports the learning process carried out. The feasibility aspect of the media being tested is related to the color and design of the game optics. The second highest aspect is the aspect of language feasibility by obtaining 2,940 points. Then the third aspect is the aspect of material feasibility with 2.801 points obtained. Aspects of the feasibility of the material, in this case, include the feasibility of the content of the material, the behavior of the ease of the material to be understood and the level of feasibility of the material to increase student interest in learning. Several examiners considered that this optics game was feasible of being used as an alternative media to increase students' interest in learning. This is in line with research conducted by Sujalwo (2017), one of the methods that can be used is game-based learning, namely the use of games as learning media. There are several suggestions from the examiners regarding the material that should be made more concise, providing more varied examples of images, using brighter colors, and also regarding choosing a more attractive font style.

From the results of the feasibility test, it can be seen that the optics game learning media is in the feasible category. Therefore, we hope that this research can be continued in the manufacture of products and can be widely published. So that later it can be used as an alternative to increase students' interest in learning , especially in light interference and diffraction .

D. Conclusion

The conclusions obtained from the research conducted are that the learning media in the form of optics game is used as an alternative learning to increase students' interest in learning about light interference and diffraction materials. The results of the feasibility test of the optics game product were declared eligible.

Acknowledgments

In this study, the researcher would like to thank the respondents and those who have been willing to help make this research a success so that it can be carried out properly.

Bibliography

[1] A. N. Hikmah, & Chudzaifah, I. “Blended Learning: Solusi Model Pembelajaran Pasca Pandemi Covid-19”, Al-Fikr: Jurnal Pendidikan Islam, vol. 6(2), pp. 83-94, 2020.

[2] Minister of Education, Culture, Research and Technology, “Circular Letter of the Minister of Education, Culture, Research and Technology Number 2 of 2022 concerning Discretionary Implementation of the Joint Decree of the four

Ministers regarding Guidelines for Organizing Learning During the 2019 Coronavirus Disease Pandemic (Covid-19) *(Surat Edaran Menteri Pendidikan, Kebudayaan, Riset, dan Teknologi Nomor 2 Tahun 2022 tentang Diskresi Pelaksanaan Keputusan bersama empat Menteri tentang Panduan Penyelenggaraan Pembelajaran di Masa Pandemi Coronavirus Disease 2019 (Covid-19))", 2019.*

[3] Sulistyorini, D. E. W, "Instagram-Based Entrepreneurship Building Creative Learning Solutions in the Middle of the Covid-19 Pandemic *(Entrepreneurship Building Berbasis Instagram Solusi Pembelajaran Kreatif di Tengah Pandemi Covid-19)",* Jurnal Guru Dikmen dan Diksus, vol. 4(1), pp. 1-11, 2021.

[4] Sujalwo, S., & Sukirman, S, "Game Berbasis Web Sebagai Media Pembelajaran Fisika Interaktif Untuk Siswa SMP", in Seminar Nasional Pendidikan Berkemajuan dan Menggembirakan (The Progressive & Fun Education Seminar) ke-2, 2017.

[5] Ramadhan, H. F., Sitorus, S. H., & Rahmayuda, S, "Game Edukasi Pengenalan Budaya Dan Wisata Kalimantan Barat Menggunakan Metode Finite State Machine Berbasis Android *(Educational Game Introduction to West Kalimantan Culture and Tourism Using the Android-Based Finite State Machine Method)*" Jurnal Komputer dan Aplikasi, vol. 07(1), pp. 108-119, 2019.

[6] Lutfia, W, "Analisis Profil Pemahaman Konsep Dan Model Mental Siswa Di Sma Kesatrian 2 Semarang Pada Materi Interferensi Dan Difraksi Cahaya *(Profile Analysis of Understanding Concepts and Mental Models of Students at SMA Kesatrian 2 Semarang on Interference and Light Diffraction Materials)*", Thesis, Fakultas Matematika Dan Ilmu Pengetahuan Alam, Universitas Negeri Semarang, 2019.

[7] Mulyatiningsih, E. Applied Research Methods in the Field of Education (*Metode Penelitian Terapan Bidang Pendidikan)*. Bandung: Alfabeta. 2012.

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Skilled in Creating Power-Reducing Products for E-Size Guitar Strings (Star Missiles) through Project-Based Learning Models

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ABSTRACT

This research was conducted in mathematics and sciences class XII-2 high school 1 Sigaluh, on electromagnetic induction material. The data of this research are data improving science process skills and scientific attitudes. The research instruments are in the form of observation sheets for project implementation assessments and questionnaires. The results of the questionnaire show that 63% of respondents use electricity-saving lamps, 31% have not used electricity-saving lamps, and 6% choose to be absent. The results of observation on the star missile PjBL showed an average of 81 categories of the high predicate. The results of the science teacher's response questionnaire obtained a score with the predicate category that strongly agrees with the star missile project-based learning. While the results of the cognitive assessment of the Star Missile PjBL have an average of 85, project appraisal with an average of 83.8 for star missile product appraisal has an average score of 85.8. Based on the results, it can be concluded that the application of the star missile project-based learning model can improve science process skills and scientific attitudes and is expected to can provide input for Physics teachers in implementing the star missile project-based learning model on KD 4.5.

INTISARI

Penelitian ini dilaksanakan di Kelas XII SMAN 1 Sigaluh, Materi Induksi Elektromagnetik dengan subyek penelitian adalah Kelas XII mathemati 2. Data penelitian ini adalah data tentang peningkatan keterampilan proses sains dan sikap ilmiah. Instrumen penelitian berupa lembar pengamatan penilaian pelaksanaan proyek dan angket kuisioner. Hasil kuisioner tentang perilaku hemat energi listrik menunjukkan, 63% responden menggunakan lampu hemat listrik, 31% belum menggunakkan lampu hemat listrik, dan 6% peserta didik memilih absen. Hasil angket lembar observasi peserta didik dalam proses pembelajaran berbasis proyek rudal star dengan indikator pertanyaan empat soal menghasilkan rerata 81 kategori predikat tinggi. Hasil kuisioner tanggapan guru IPA tentang pembelajaran berbasis proyek rudal star memperoleh nilai dengan kategori predikat sangat setuju dengan pembelajaran berbasis proyek rudal star. Sedangkan hasil penilaian Kognitif tentang pembelajaran proyek rudal star memiliki rata-rata 85, penilaian proyek dengan rerata 83,8 untuk penilaian produk rudal star memiliki rata-rata nilai 85,8 dengan nilai (KKM) sekolah 65. Berdasarkan hasil analisis data dan pembahasan hasil penelitian, dapat disimpulkan bahwa penerapan model pembelajaran berbasis proyek rudal star dapat berkontribusi positif pada peningkatan keterampilan proses sains dan sikap ilmiah dan diharapkan dapat memberikan masukan bagi guru Fisika dalam menerapkan model pembelajaran berbasis proyek rudal star pada KD 4.5.

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A. Introduction

Physics is the study of natural phenomena or in other words, physics is an empirical science, because it is empirical, so observations and experiments are the main things. So that student are led to make direct contact with the object under study. With direct contact with objects, students carry out scientific products, scientific processes, and scientific attitudes. Today, there are still students who are apathetic toward physics subjects [1]. They justify that Physics subjects are complicated and difficult to understand so they are less able to explore existing learning resources. In addition, students lack a scientific attitude which affects the learning atmosphere, students feel uncomfortable, and lack interaction well, lack of cooperation, resulting in less effective communication, and less activity and creativity so that they do not develop thinking that learning objectives are not achieved,

teachers have not been precise in describing/analyzing basic competencies (KD) as indicators of competency achievement (GPA), as a result, the materials and learning activities designed are not in accordance with the expectations of the basic competencies (KD) [2]. In the odd semester of the mathematics and sciences class, XII-2 for the physics subject, such as in KI 4 skills in KD 4.5 is creating simple products using the principle of electromagnetic induction. The teacher rarely notices the assessment of skills at KD 4.5, the teacher has not been able to direct the students to what products will be created, and the time is not sufficient because the time is more concerned with preparation for the implementation of the School Examination (US), the teachers make a greater percentage of e right to perform cognitive assessments.

Teachers are less innovative in the application of models, methods, and learning approaches that are in accordance with the material to be delivered [3].Teachers do not apply the subject matter contextually in everyday life, so the message conveyed is not well received by the students. Teacher creativity about the development of learning media is less supportive so students are less active in learning activities. Teachers also do not understand the concept of 21st-century skills and strengthening character education (PPK) in application to the learning process so the assessment has not been authentic or comprehensive, both cognitive, psychomotor, and affective.

To encourage students' ability to produce contextual work, both individually and in groups, one of the Learning Implementation Plans (RPP) in the learning process uses the Project Based Learning (PjBL) model [4]. Encouraging by the PjBL, we proposed electronic media to fulfill the educational needs. This tool stabilizes the electromagnetic current when the electronic device is first turned on. This tool is called the Star Missile (Guitar String Electronic Power Reducer) which is made of E guitar strings (the smallest size) and is shaped like a solenoid coil (coil). The guitar strings are embedded into a 1.5-inch pipe using white cement. The two ends of the coil are connected to the socket, and the other is connected to the jack. This way, we expect the result to be close to being a ref Yuliani [5] and Kolai [6].

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B. Method

The method used in this research is a quantitative method of experimental explanation. This method is very effective for data collection in order to measure the effect or effectiveness of a tool, or media under certain conditions [7]. In this study, the implementation of the Star Missile project activity was the independent variable and the student's scientific attitude was the dependent variable. The data collection method used in this research is in the form of quantitative data. Data collection techniques using observations by filling out questionnaires. The population is students in the mathematics and sciences class XII-2 odd-semester on electromagnetic waves.

The instrument used to collect data on science process skills is based on the Star Missile project-based learning observation sheet in the form of an observation sheet project implementation assessment, the aspects assessed are planning, implementation, and project final report. The result of the assessment is in the form of a score that is worth a number which states the predicate is good, sufficient, or less. In the product assessment sheet, the aspects that are assessed are the planning of materials and tools, the manufacturing process, and product results, from the three aspects of the assessment it is reduced to nine question indicators. The assessment score is in the form of a numerical score that has a predicate. To find out the understanding of the process of making Star Missiles, students are provided with worksheets (LKPD). The instrument used to observe the scientific attitude of students in participating in the Star Missile project-based learning using a questionnaire in the form of learning implementation, motivation for the implementation of PjBL Missile Star, and Evaluation of project results reports, with an assessment score in the form of numbers stating strongly agree, agree, disagree and strongly disagree.

The data analysis used in this research includes observational analysis and questionnaire analysis. Each observation has a scoring grid and rubric. The observational analysis includes science process skills, project product assessment, and assessment format for project learning activities implementation. The questionnaire analysis includes a questionnaire on household consumer behavior towards energy-saving behavior, as well as a scientific attitude questionnaire on the Star Missile project-based learning. The analysis is carried out with the following steps:

1. Give a score at the time of assessment
2. Calculating the scores obtained by students with the observation sheet
3. Calculating the total score obtained by students
4. Calculating the ability of science process skills in Star Missile project-based learning with the formula:
   a. The ability of science process skills in project-based learning

$$N = \frac{X}{T}\ 100\% \qquad (1)$$

N : Number of Missile

X : The total value obtained

T : Total Score

b. Analysis of Scientific Attitude Questionnaire

The scientific attitude assessment is in the form of a rating scale observation sheet using a Likert scale accompanied by a rubric. Next, calculate the percentage of student response questionnaire scores using the formula (1). Analysis of the questionnaire data by scoring the answers on the answer choices with the following criteria:

Score 5	= Strongly agree	= Very high
Score 4	= Agree	= High
Score 3	= Disagree	= Moderate
Score 2	= Disagree	= Low
Score 1	= Strongly disagree	= Very Low

With the Observation scoring rubric on scientific attitudes and science process skills of students in participating in Star Missile project-based learning activities

Table 1. Questionnaire scoring rubric

Level of success	Predicate
86 – 100%	Very high
71 – 85 %	Tall
56 – 70%	Currently
41 – 55%	Low
< 40	Very low

The stages of this research activity are based on pre-programmed and systematic methods. There are four stages which are divided into several activities for each meeting. The following shows the method of solving the problem in tabular form.

Table 2. Method of implementation of PjBL Missile Star

Stages	Activity
1. The initial activity is to find out students' understanding of electrical material	Distributing household consumer behavior questionnaires about electricity-saving behavior
2. The use of Star Missile RPP by using Method: lecture, discussion, question, and answer, using PowerPoint media	1. Explanation of the basic concept of Star Missile 2. Doing Student Worksheets on Electromagnetic Induction Experiments 3. Random division of groups by distributing rolls bearing the name of the animal, by mentioning the sound of the animal while in groups (4-5 children per group) 4. Discuss with the Star Missile LKPD guide 5. Presenting the results of the Star Missile LKPD 6. Assessment during teaching and learning activities

Stages	Activity
3. The use of the Star Missile RPP using the Star Missile PJBL Model, methods, lectures, discussions, and experiments	1. Creating a project implementation grid 2. Technical explanation of the implementation of the Star Missile project 3. Project implementation for 2 – 3 weeks 4. Project activity assessment 5. Product Rating 6. Assessment of skills and attitudes on student observation sheets by teachers and collaborators 7. Upload videos to youtube 8. Writing the Star Missile Implementation Report
4. Questionnaire filling	1. Questionnaire of science teachers' responses to implementing PjBL Missile Star 2. Questionnaire of student responses about learning the Star Missile project

C. Results and Discussion

To encourage students' ability to produce contextual work, both individually and in groups based on the Star Missile Project as an alternative to completion in KD 4.5 Creating simple products using the principle of electromagnetic induction. Star missile tool making is very simple, utilizing existing used materials, materials, and tools are easy to obtain and do not take a long time in the manufacturing process. With the main ingredients of size E guitar strings, pipes, and white cement, it can be an alternative to overcome Electromagnetic blackouts (falls) if you turn on electronic devices simultaneously with unbalanced Electromagnetic power (lowering power on electronic devices). So the hope is that Star Missile project-based learning can improve cognitive abilities, and scientific attitudes and improve science process skills.

1. An initial understanding of the behavior of household consumers towards the behavior of saving electrical energy

The results of a questionnaire about the behavior of household consumers towards electrical energy-saving behavior in class XII MIPA students of High School 1 Sigaluh have a function to find out how deep the concept of alternating current (AC) electricity is in its application in everyday life, the results of the questionnaire on the behavior of household consumers towards the behavior of saving electrical energy also provide supplies and instill an attitude or cultivate a culture of saving electricity. The results of the questionnaire also provide a sample picture of students' attitudes about electricity-saving behavior in High School 1 Sigaluh. The number of respondents filling out a questionnaire about the behavior of household consumers towards the behavior of saving electrical energy is 35 students. The number of questions is 31 questions by choosing one of several answers. Consists of two parts of questions, the questions in the first part contain the identity of the respondent, the second part contains the behavior of saving electricity. The following will present

some of the results of the electricity-saving behavior questionnaire. Several other questionnaire results are explained in the appendix of this study.

Based on the results of a questionnaire analysis on an identity consisting of name, gender, class, address, age, class classification of home electricity customers, types of electronic equipment used, and the average number of monthly electricity payments on electricity consumer behavior towards electricity-saving lifestyles, some students of class XII-2 majoring in science with the number of respondents 35 students with the age of most 17 years 85 % of the total number.

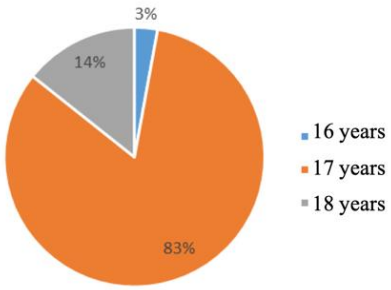

Figure 1 . Age of respondents for saving electricity

The results of the questionnaire on the class classification of home electricity customers on the respondents showed that 51% had a home power capacity of 450 Watts. The electric power capacity of 900 Watts shows a yield of 46% while the more 3% has a home power capacity of 1300 Watts.

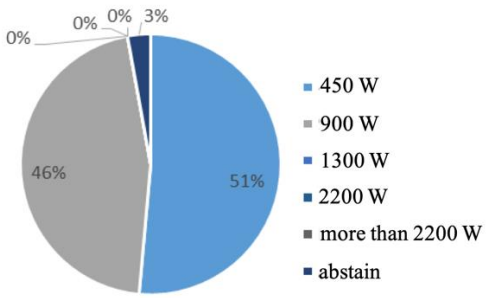

Figure 2. Class classification of respondents' home electricity customers

The results of the questionnaire regarding the class classification of the largest home electricity customer have an electric power capacity of 450 Watts, these results also show that the types of electronic equipment that are turned on are limited. This proves that the Star. The missile is needed in helping to simultaneously turn on several electronic devices.

Several electricity-saving measures based on the results of the questionnaire show that most of the students of mathematics and sciences class XII-2 High School 1 Sigaluh do not understand electricity-saving measures in the application of daily life.

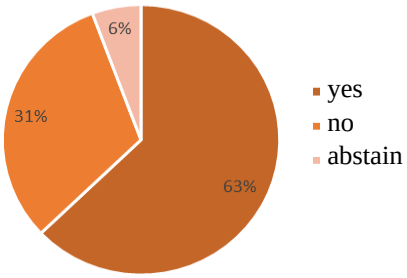

Figure 3. The respondent's use of electricity-saving lamps

The house lighting used by some respondents has not used electricity-saving lamps. Approximately 31% have not used electric energy-saving lamps. The percentage of respondents' reasons for not using electrical energy-saving lamps is that electric energy-saving lamps are expensive 31%, electrical energy-saving lamps are difficult to obtain 4%, there is no guarantee that electric energy-saving lamps will be more efficient 26%, the choice of other reasons is 35%, This shows that some respondents still do not understand some electrical energy-saving measures. The percentage of the reasons for choosing energy-saving lamps is illustrated in the figure 4 below.

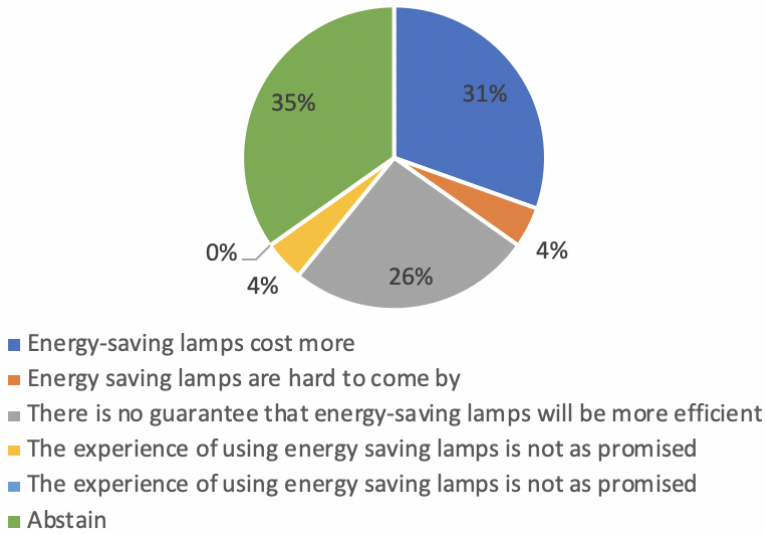

Figure 4 . Electric energy saving lamp response

About 60% of respondents chose the peak load time on their home network from 17.00 to 22.00 WIB.

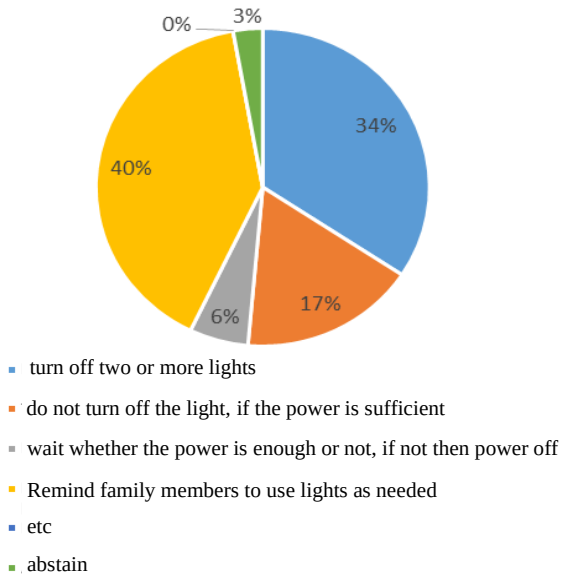

Figure 5. Energy saving measures

The reason for choosing the time was because at that time all the lighting was on, and most of all family members were at home with various activities related to the use of electrical energy. Approximately 40% of respondents choose the action of reminding family members to use lights according to their needs, respondents have not taken concrete actions based on their awareness to take action to save electricity. For this reason, it is necessary to provide a more contextual explanation of concepts for the application of electrical energy-saving materials in everyday life.

2. The results of the student's observation questionnaire regarding the scientific attitude of implementing the Star Missile Project-based learning implementation on the material of Mathematics and Sciences Class XII-2 in the odd-Semester Electromagnetic Induction by subject teachers and collaborators

This questionnaire aims to collect data about the scientific attitude of students in participating in learning activities based on the Star Missile project conducted by subject teachers and collaborators during the implementation of learning. There are nine (9) observations about the scientific attitude of students during the implementation of the Star Missile project-based learning. Subject teachers and collaborators are recommended to choose a score according to their own choice by placing a checklist (v) in the score column (5,4,3,2,1) according to the following criteria 5 very high, 4 high, 3 moderate, 2 low, 1 very low.

Questionnaire data processing on the scientific attitude of students in participating in Star Missile project-based learning activities refers to (Source: adaptation from Agip et al: 41) with the acquisition of a percentage range of values to

determine very high, high, medium, low, and very low predicates. The results obtained by twenty-five (25) students are shown in the following figure 6 :

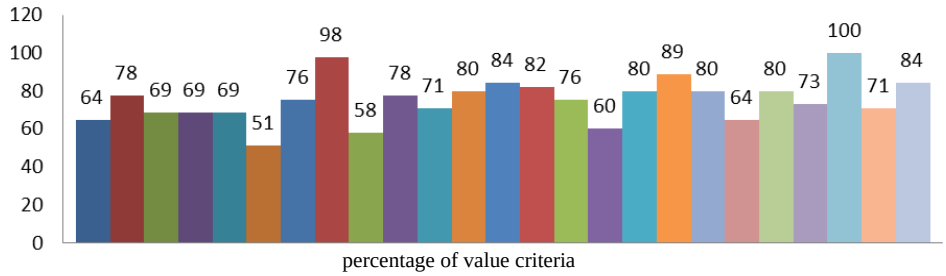

Figure 6. The results of the students' scientific attitude questionnaire scores

Based on the score acquisition table, the percentage of predicates is very high, high, and medium in the questionnaire regarding the scientific attitude of implementing Star Missile Project-based learning on the material of mathematic and sciences class XII-2 in the odd Semester High School 1 Sigaluh shown in the following figure 7:

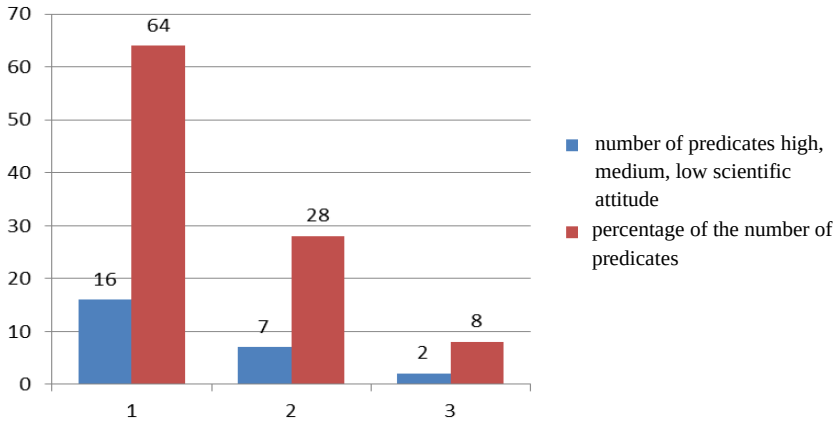

Figure 7. Results of the percentage of scientific attitude predicate

The number of respondents filling out the scientific attitude questionnaire was twenty-five (25) students. The data obtained in the number of very high predicate percentages were 16 students so the percentage showed 64%, seven (7) high predicates showed a 28% percentage, while the low predicate 2 students showed an 8% percentage.

The results of the descriptive analysis of the questionnaire regarding the scientific attitude of implementing learning based on the Star Missile Project on the material of Electromagnetic Induction Class XII MIPA Odd Semester High School 1 Sigaluh as many as 25 respondents who chose very high as many as 16 respondents in the implementation of the Star Missile Project-based learning. This fact shows that the Star Missile project-based learning is very appropriate and an alternative to one of the most appropriate learning models for analyzing KD 4.5 Creating simple products using the principle of electromagnetic induction to improve students' scientific attitudes. Students are more enthusiastic when learning, students attention to teachers when delivering material, activeness in asking about students' skills in opinion or

criticism, interact in conducting discussions, order when following the learning process, the appearance of work results, and work on worksheets/ evaluation of learning outcomes become indicator measure of the achievement of the scientific attitude of students

3. The results of the student observation sheet questionnaire in the Star Missile Project-based learning process on the material of Class XII MIPA Odd Semester Electromagnetic Induction

To strengthen the results of the student's observation sheet data about the Star Missile project-based learning by the collaborators above, we also measured student responses questionnaires regarding the Star Missile Project-based learning. There are three indicators in the questionnaire regarding the implementation of the Star Missile Project-based learning on Electromagnetic Induction material, namely 1) regarding the implementation of learning described in eight (8) questions, 2) motivation for implementing the Star Missile project learning described in four (4) questions. , 3) evaluation of the project report described in three (3) questions, so that the total number of questions is fourteen (14) questions.

Students are encouraged to choose a score that is in accordance with their own choice by marking a checklist (v) in the score column (5,4,3,2,1) according to the following criteria 5 very high, 4 high, 3 moderate, 2 low, 1 very low. With the Observation scoring rubric on the scientific attitude of students in participating in Star Missile project-based learning activities.

Based on the results of the questionnaire data on student responses about the Star Missile project-based learning process based on the assessment rubric, the results are shown in the figure 8 below:

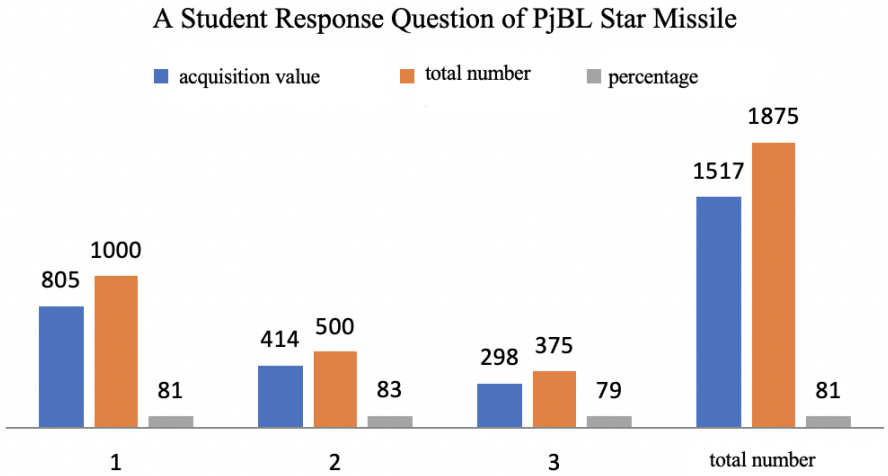

Figure 8. Student responses about PjBL Missile Star

The results of each indicator are presented in the graph above, the first indicator, namely the implementation of learning, shows the respondent's acquisition value with a total of 805, with a total of eight (8) questions descriptions with a maximum score

of five so that the total number of questions is worth 1000. By comparing the short score with the total number of questions. the average score of the indicator multiplied by 100% produces a score of 81, based on the rubric of assessment with a value of 81 indicating a high predicate. The second indicator, namely the motivation for PjBL Missile Stars, shows a total score of 414 respondents, with a total of four (4) question descriptions with a maximum score of five so the total number of questions is worth 500. Comparing the short-lived score with the total number of indicator scores multiplied by 100 % resulted in a score of 81, based on the rubric of assessment with a value of 83 indicating a high predicate. The third indicator, namely the motivation for PjBL Missile Stars, shows a total score of 298 respondents, with a total of three (3) question descriptions with a maximum score of five so the total number of questions is worth 375. Comparing the short-lived score with the total number of indicator scores multiplied by 100 % resulted in a score of 81, based on the rubric of assessment with a value of 81 indicating a high predicate. While the total average of the three indicators produces a percentage value of 81 with a high predicate.

The results of the student response questionnaire calculation data above further strengthen the results of the collaborator's questionnaire data on the Star Missile project-based learning process. The results of both data analyses showed high predicate. This shows that the Star Missile project-based learning model is very appropriate as a learning model in KD 4.5 Creating simple products using the principle of electromagnetic induction to improve students' scientific attitudes.

4. Questionnaire analysis of science teachers' responses to the process of PjBL Missile Star High School 1 Sigaluh

The missile star project-based learning is in practice assisted by science teacher collaborators. The role of peer teachers, especially science teachers, plays an important role in research, not only as collaborators but also as assessors of activities through a questionnaire on the implementation of Missile Star project-based learning activities. There are five (5) science teachers in High School 1 Sigaluh, one physics teacher, two biology teachers, and two chemistry teachers. The science teacher of High School 1 Sigaluh assessed the implementation of the Star Missile project-based learning by filling out a questionnaire. The teacher's response questionnaire on the implementation of Star Missile project-based learning has three indicators, namely 1) the implementation of PjBL Missile Starter contains eight statements, 2) Motivation towards the implementation of PjBL has two statements, 3) Evaluation of the project results report has two statements. The science teacher filled out the questionnaire by putting a checkmark in the score column (5,4,3,2,1) with the following criteria 5 strongly agree, 4 agree, 3 disagree, 2, disagree, and 1 strongly disagree. The results of the teacher's questionnaire on the implementation of the Star Missile project-based learning are shown in the following table 3:

Table 3. Table of responses from science teachers regarding the Star Missile PJBL

Indicator	Statement	Score	Percentage	Category	Rubric
Implementation of Star Missile PjBL	8	35	87	Strongly agree	30 – 40 = strongly agree, 19 – 29 = agree 8 – 18 = disagree
Motivation towards the implementation of Star Missile PjBL	2	10	100	Strongly agree	8 – 10 = strongly agree 5 – 7 = agree 2 – 4 = disagree
Project result report evaluation	2	9.5	95	Strongly agree	8 – 10 = strongly agree 5 – 7 = agree 2 – 4 = disagree

The results of the data on the teacher's response questionnaire about the Star Missile project-based learning above as a whole is illustrated in the following Table 4:

Table 4. The results of the science teacher questionnaire responses

Name	Score	Percentage
Teacher 1	49	82
Teacher 2	57	95
Teacher 3	55	92
Teacher 4	56	93

The results of filling in the teacher's response questionnaire regarding the implementation of Star Missile project-based learning show the results strongly agree on the three indicators. This shows that the Star. Missile project-based learning model very appropriate for KD 4.5 Creating simple products using the principle of electromagnetic induction to improve students' scientific attitudes.

5. Star Missile Science Process Skill Assessment

The Star Missile project-based learning process aims to measure students' scientific attitude as well as assess the science process skills of Star Missile project-based learning in accordance with KD 4.5 Creating simple products using the principle of electromagnetic induction. The assessment of the science process skills of Star Missiles is in the form of project learning assessments, project product assessments, and cognitive assessments of the concept of making Star missiles through Student Worksheets (LKPD). Project learning assessment and project product assessment are in the form of an assessment format that has a score by ticking and has an assessment rubric with a certain range. The three results of the Star Missile project-based learning science process skills assessment are as follows:

Table 4. Results of the Star Missile Science Process Skill Assessment

Group	Cognitive Value 1 (LKPD)	Cognitive Value 2 (LKPD)	Project Appraisal	Project Product Appraisal
1	87	86	91.6	84
2	85	76	86.1	90.6
3	89	89	80.5	87.5
4	84	84	77	81

The results of the assessment of the science process skills of the Star Missile project have met the Teaching Completeness Criteria (KKM) for Physics subjects at KD 4.5, namely 65. These results indicate that the Star Missile project-based learning activities make a positive contribution to improving science process skills and scientific attitudes in KD 4.5 Creating a simple product using the principle of electromagnetic induction.

D. Conclusion

Based on the results of the analysis and discussion of the implementation of the Star Missile project-based learning, it can be concluded that the use of the Star Missile project-based learning model as an alternative is more appropriate for use in KD 4.5 Creating simple products using the principle of electromagnetic induction. Based on the assessment of subject teachers and collaborators on the results of observations through filling out questionnaires, it shows that 64% of students are enthusiastic about participating in Star Missile project-based learning. The use of the Star Missile-based learning model can improve science process skills, and scientific attitudes and increase student achievement. This is reinforced by the results of the questionnaire analysis of student responses about the Star Missile-based learning process showing a score of 81% with a high predicate. The cognitive assessment shown from the results of working on the worksheets (LKPD), product assessments, and project results report assessments showed scores that exceeded the school's minimum completeness criteria. The use of the Missile Star project-based learning model can improve student achievement, science skills, and scientific attitude. Considering that the application of the Missile Star project-based learning model can improve scientific attitudes and science process skills in Physics subjects, teachers need to apply them in the learning process at school by innovating more on the size of guitar strings.

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Bibliography

[1] D. Daryani, Pengajaran yang kretif dan menarik. Jakarta: PT. Index, 2009.
[2] H. Haryadi, Penilaian Hasil Belajar. Bandung: CV. Wacana Prima, 2007.
[3] S. Suwandi, Model Assesmen dalam Pembelajaran. Solo: Mata Padi, 2009.
[4] S. Anitah, Media Pembelajaran. Jakarta: Yuma Pustaka, 2009.
[5] H. Yuliani, Physics Learning with Process Skills Approach with Experimental and Demonstration Methods in View of Scientific Attitude and Analytical Ability (Study on Static Fluid Learning Materials for Class XI Semester 2 Students of SMA Negeri 1 Jakenan Pati T (*Pembelajaran Fisika dengan*

Pendekatan Keterampilan Proses dengan Metode Eksperimen dan Demonstrasi Ditinjau dari Sikap Ilmiah dan Kemampuan Analisis (Studi pada Materi Pembelajaran Fluida Statis untuk Siswa Kelas XI Semester 2 SMA Negeri 1 Jakenan Pati T) (Doctoral dissertation, UNS (Sebelas Maret University), 2012.

[6] K. Kolai. Zainudin, and Suryani, "Increasing student learning activities through the application of experimental methods in class IV science learning *(Peningkatan aktivitas belajar peserta didik melalui penerapan metode eksperimen pada pembelajaran IPA kelas IV)*", Jurnal Pendidikan dan Pembelajaran Katulistiwa (JPPK), vol.1, pp.1-13, 2016.

[7] B. Bungin, Metode Penelitian Kuantitatif. Jakarta: Prenada Media, 2005.

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Implementation of an Inquiry Model Assisted with PHET and Teaching Aids to Improve Vocational Students' Learning Outcomes in The Sound Waves Concept

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ABSTRACT

Physics learning still tends to be conventional and very rarely takes place using practicum media, so students become less enthusiast. This is contrary with students in vocational schools who tend to learn through practice. This study aims to determine the effect of guided inquiry model assisted with PhET media and teaching aids in physics learning outcomes of class X students of SMKN 3 Technology and Engineering Jayapura on the sound waves concept. This study used the pre-experimental method with one group pretest-posttest design, the research sample was selected from two (control and experimental class) of nine classes through a purposive sampling technique with 25 students each group. The study used pretest and posttest essay questions which were validated by experts. The pretest and posttest data were then tested for normality and the results were normal, then N-gain analysis and hypothesis testing α = 5% significance value were performed. The results of the N-gain analysis obtained were 0.70 where the average value of the posttest>pretest ranged from moderate to high for the experimental class while the N-gain was 0.57 where the average posttest>pretest ranged from low to moderate for the experimental of class control. The results of the hypothesis test were found ($t_{count} < t_{table}$) = (0,000 < 0,05) where H_0 was rejected, so that there was an improvement in learning outcomes and there were differences in learning outcomes before and after learning with treatment in experimental class. The success of this treatment can be seen from the enthusiasm of the students who are involved independently in operating the PhET application on computer media and visual aids during learning. This learning pattern can be applied by readers/teachers in researchers but also in the development of teacher learning towards students' understanding of physics concepts.

INTISARI

Pembelajaran fisika masih cenderung konvensional dan jarang menggunakan media praktikum, sehingga siswa menajdi kurang antusias. Hal ini kurang sesuai dengan karakteristik Sekolah Menengah Kejuruan (SMK) yang mengharuskan banyak praktik dalam pembelajaran. Penelitian ini bertujuan untuk mengetahui pengaruh penggunaan model inkuiri terbimbing berbantu media PhET dan alat peraga dalam pembelajaran fisika untuk meningkatkan hasil belajar siswa kelas X SMKN 3 Teknologi dan Rekayasa Jayapura pada konsep gelombang. Penelitian ini menggunakan metode pra eksperimen dengan one group pretest-posttest design, sampel penelitian dipilih dari 2 kelas dari 9 kelas melalui teknik purposive sampling yaitu kelas X TKJ 2 (kelas kontrol) dan kelas X KGSP (kelas eksperimen) beranggota masing-masing 25 siswa. Instrumen tes berupa soal esay untuk pretest dan posttest telah divalidasi oleh ahli instrumen. Data pretest dan posttest dilakukan uji normalitas dan analisis N-gain, serta pengujian hipotesis

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dengan signifikansi α = 5%. Hasil analisis N-gain yang diperoleh sebesar 0,70 dengan nilai rata-rata posttest>pretest dari kisaran sedang sampai tinggi untuk kelas eksperimen, sedangkan pada kelas kontrol N-gain sebesar 0,57 dengan nilai rata-rata posttest>pretest dari kisaran rendah sampai sedang. Hasil Uji hipotesis menunjukkan (thitung < ttabel) yaitu (0,000 < 0,05) dimana H0 ditolak, artinya ada peningkatan hasil belajar dan ada perbedaan hasil belajar sebelum dan sesudah pembelajaran dengan perlakuan pada kelas X. Keberhasilan perlakuan ini terlihat dari antusiasme siswa yang terlibat secara mandiri dalam mengoperasikan aplikasi PhET pada media komputer dan alat peraga selama pembelajaran.Pola Pembelajaran ini dapat diterapkan oleh pembaca/guru dalam penelitia tapi juga dalam pengembangan pembelajaran guru terhadap pemahaman kosep fisika siswa.

A. Introduction

Physics science or what is called Physics lesson is a matter of science that studies a lot of natural phenomena or events that occur by looking at the relationship between substances/concepts, energy and forming variables that accompany them in every natural phenomenon, to the products produced [1]. Physics is a scientific family that is very closely related to human daily life, so in learning it really requires understanding rather than memorization. Natural phenomena that occur in evidence also require process and perseverance to be able to obtain a product scientifically [2]. This is in accordance with the nature of physics itself and in line with the demands of educational goals.

There's a stigma often arises that considers physics as an abstract subject and is mathematically difficult. The stigma keeps getting stronger among students when learning physics tends to work on mathematical problems. Besides that, some teachers have claimed for implementing student centered in learning physics, but in fact the class still leads to teacher centered so that it seems conventional coupled with the lack of collaboration in learning media that attracts sense of enthusiasm that comes from the students itself (act initiative and find concepts), as a result students do not understand the concept and have an effect on low learning outcomes. This condition also occurs in class X students at SMKN 3 Technology and Engineering Jayapura. In learning physics, students show less enthusiasm for learning, they tend to listen to the presentation rather than involve themselves. Based on the results of interview observations with three teachers at SMKN 3 Technology and Engineering Jayapura, it was found that the teachers had implemented learning that led to a scientific approach, and also applied the guided inquiry model in learning using simple experiments.

In addition, based on an interview with the students, it was found from their statements that there had indeed been simple demonstrations in physics learning, but very rarely there were experiments with learning media in the form of learning applications or teaching aids. Learning did last a long time but was more dominant in taking notes, doing assignments, and listening to lectures, so that "students" had

difficulty understanding the simple concepts discussed. This gives the impression that student participation is only for attendance fulfillment, which has an impact on a lack of understanding of concepts and physics learning outcomes. Students with average scores ranging from 30-65, resulting in a low outcome. The use of appropriate learning patterns can make students involve themselves and participate actively and gain as much understanding as possible about the object being studied so that they can collaborate and apply this knowledge in their surroundings [3]. The learning patterns in question include the use of approaches, models, methods, learning media.

One of the appropriate use of models in learning physics is the Guided Inquiry model [4]. The guided inquiry model is a student-oriented learning model where the teacher is only a quality control directing students to find relevant concepts individually or in groups in solving a problem to draw a conclusion independently [5]. The guided inquiry model allows students to be creative in acquiring knowledge by discovering it themselves [6]. A teaching model that allows students to move gradually from identifying problems, identifying hypotheses, formulating problems, collecting data, verifying results and generalizing conclusions [7]. Based on some of the opinions of previous researchers show that the guided inquiry model is a discovery learning model that is oriented towards students to be more skilled in real work that is relevant in finding out, understanding and solving scientific problems to find their own learning solutions as new knowledge for them so that they are capable to master the concept of a theory discussed while the teacher acted as a guide and controller of the process of students finding the exact answer. In addition to models, the use of media in physics learning will greatly assist students in accepting and easily understanding a concept [8]. Learning media is any kind of thing that is used to stimulate students' thoughts, feelings, attention, and willingness to learn from within themselves [9]. The use of media in the learning process can help students gain simple understanding, facilitate the interpretation of data, and condense the information [10].

Physics Education Technology (PhET) is a virtual laboratory-based learning media designed by the University of Colorado, useful as a learning simulation medium [11]. According to Abdjul and Ntobou [12] PhET is a series of laboratory tools in the form of interactive multimedia-based computer software. The PHET media operates simulation activities in the laboratory as if it brings the user to a real laboratory [8]. Learning using PhET simulations is also able to motivate students because it increases the enthusiasm and activity of students, can complete learning outcomes, and students' psychomotor [13]. According to Saregar [14] PhET makes student learning outcomes better. Apart from PhET, the same benefits apply to learning aids. Teaching aids are learning media that contain or carry concepts from the concepts being studied [15]. According to Mujahid and Kurniawan [16] visual aids are media/learning aids and all kinds of objects used to demonstrate learning concepts. Students are very enthusiastic when conducting experiments using teaching aids, there is interaction with fellow members of friends to learn further concepts [17]. Visual aids make it easier for

students to understand the concepts in the concept so that they can improve student learning outcomes [18]. The use of PhET media and teaching aids serves to show or introduce reasons for the occurrence of a problem and the solution to the problem to students. The existence of PhET media and visual aids in wave and sound learning which is implemented using the guided inquiry model makes it easier for the students themselves to actively think and act to find information independently.

Based on the background, the researcher tried to applying the guided inquiry model through PhET virtual laboratories and real simple experiments aids in the wave and sound materials to improve vocational students' learning outcomes. The purpose of this study is to see whether there is an increase in student learning outcomes. The null hypothesis (H0) in the study is that there is no effect of using PHET media and physics teaching aids on student learning outcomes of SMKN 3 Technology and Engineering Jayapura.

B. Method

The research was carried out pre-experimentally with a one-group pretest-posttest design [19]. The research design describe as follows.

$$O_1 \times O_2$$

Figure 1. One-Group Pretest Posttest Design
(Source: Sugiyono, 2015)

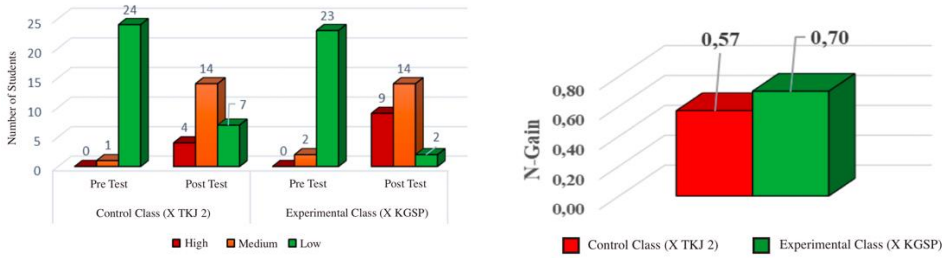
Descriptions:
$\times$: Treatment to the experimental group
O_1 : Pretest, test before the material has been given
O_2 : Posttest, test after the material has been given

The population in this study were class X students of SMKN 3 Technology and Engineering Jayapura which were divided into 9 classes. Of the 9 classes, 2 classes were taken as research samples based on learning speed and the number of sample members, namely Class X TKJ 2 (Control class) and X KGSP (Experimental class). Ways in determining the sample class was carried out using a non-probability sampling technique by purposive sampling [19].

The research instrument was a written test using 10 cognitive description questions to measure learning outcomes. Instrument feasibility tests are determined by personal experts (the experts were lecturers and practitioners). The research data were calculated using N-gain statistics using Microsoft Excel software and statistical analysis of prerequisite tests using the normality test *(Nonparametric test-1 sample K-S)*. The result showed that the data were normal. Then for the hypothesis testing, this study used different tests by paired sample T-test technique [20] which was calculated using software SPSS 16 for windows.

C. Results and Discussion

Descriptions of learning outcomes data are presented in the following figure 1:



(a) (b)

Figure 1. (a) Diagram of Improved Pretest and Posttest Results of the Concept of Waves and Sound; (b) Diagram of The Average N-gain Chart of All Waves and Sound Concepts,

Figure 1(a) shows that there was no student in the control or experimental class who got a high score, while the posttest scores of students show that students in the experimental class achieve a higher score than the control class (nine points compared to four points). 14 students in the experimental class reached the average score, and 12 students got low posttest scores. In the control class, seven students achieved an average score, while four students got a low posttest score. Figure 1(b), the learning outcomes of all sound wave concepts are seen based on the N-gain value, so that for the control class it is 0,57 in the medium category, for the experiment it is 0,70 in the high category. Figure 1 has proven that there is an improvement in learning outcomes from students in the control class and the experimental class.

The analysis continued with the prerequisite test analysis using normality test and the different test to find out whether there were differences in student learning outcomes as shown in table 1. The prerequisite test obtained the results that the data were normally distributed so that it was continued with a different test (t-test).

Table 1. Different Test Results from Pretest and Posttest Learning Outcomes of All Concepts.

Variable	Class	Class	Normality Test		Different Test	
			Sig.	Desc.	Sig.	Desc.
Learning Outcomes All Concept	Control	Pretest	0,517	Normal	0,000	There's differences
		Posttest	0,222	Normal		
	Experiment	Pretest	0,403	Normal	0,000	There's differences
		Posttest	0,212	Normal		

In hypothesis test, "There is no increase in learning outcomes, testing the null hypothesis using a different test. From the results of statistical tests performed, it was obtained sig t_{count} < significance level $\alpha/2 = 0.05$, namely 0,000 < 0,05 which means H_0 is rejected, then there are differences in learning outcomes before and after treatment, where the average posttest > pretest is dominant in the moderate category.

The research results showed that there was an improvement in student learning outcomes and there were significant differences in student learning outcomes before and after sound wave learning using the guided inquiry model assisted by PhET media and teaching aids. This is evidenced from the acquisition of hypothesis testing with a significance value less than 0,05 (0,00 < 0,05). The posttest scores of students show that students in the experimental class achieve a higher score than the control class (nine points compared to four points) (see Figure 1(a)). The differences in learning outcomes is also shown in the N-Gain result of the overall concept between the two classes is 0,57 for the moderate category of the control class and 0,70 for the moderate category of the experimental class. The difference in N-Gain between the two classes is 0,13 which means there are differences in learning outcomes between classes X TKJ 2 and X KGSP.

This situation for the researcher has presented that the implementation of the guided inquiry model assisted by PhET media and teaching aids has changed the improvement of learning outcomes for students.

Learning that takes place using the guided inquiry model assisted by PhET media in this study helps students find concepts that are abstract to the average eyesight, while the use of guided inquiry models assisted by teaching aids represents learning material that is tangible and can be developed independently so that it can be better understood by students. Based on the study, the application of the guided inquiry model assisted by PhET media and teaching aids can improve the learning outcomes of class X students of SMKN 3 Engineering Technology Jayapura on the concept of sound waves which is evident from the results of learning outcomes for all sound wave concepts of experimental class students from an N-gain value of 0,70 category to high while students in the N-gain control class were 0,57 in the medium category.

These results are consistent with Sukma's research that the guided inquiry learning model makes a positive contribution to student learning outcomes. The implementation of physics learning using the guided inquiry model can improve student learning outcomes in the concepts of vibration, waves, and sound [4]. The application of simulation media using PhET can improve physics learning outcomes in the medium category in class X students [8]. Maretasari et al. [21] showed that research obtained a learning gain of 0,53 proving that the laboratory-based guided inquiry model has a significant positive effect on learning outcomes and students' scientific attitudes.

Previous research by Purwanto et al. [22] found that there were differences in student learning outcomes in learning using PhET media and Teaching Aids. Besides, Ernita et al. [23] explained that there were significant differences in the cognitive physics learning outcomes of students who used real and virtual laboratory-based guided inquiry learning models at a significant level of 5% besides that there were differences in learning outcomes of students who studied using virtual learning media

PhET-based laboratory (0,70) with results using simple teaching aids (49,56) through the guided inquiry learning model [12].

Learning with guided inquiry is reinforced by the results of Simbolon [24], which showed that there was a significant difference between the gains in physics learning outcomes taught using guided inquiry learning models based on real experiments and virtual laboratories compared to students taught using direct learning models. The results showed that there was an improvement in student learning outcomes with a presentation of 72% in the high category [24] The research results were also obtained by Maretasari et al., [21]that there was an increase in learning gain of 0,53 which was categorized as high from learning that applied the laboratory-based guided inquiry model which had a significant positive effect on learning outcomes.

D. Conclusion

The Guided Inquiry Model is better at increasing the gain in Physics learning outcomes. Based on the finding in this study, collaborative learning treatments using guided inquiry model can help students gradually bring up skills from themselves and independently through group discussions properly, and make students able to remember the concepts in a short time. It was proven in the study that students made conclusions and evaluated learning. Students were able to convey their understanding using their words whose meanings were appropriate with the physics concepts. However, behind the advantages of this media and model it also has disadvantages, namely the use of PHET media on computers and teaching aids which are limited to be used by each student. Therefore, it takes quite a long time to provide opportunities for students to try experimenting.

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Bibliography

[1] Subekti Y., Ariswan A, "Learning Physics with Experimental Methods to Improve Cognitive Learning Outcomes and Science Process Skills *(Pembelajaran Fisika dengan Metode Eksperimen untuk Meningkatkan Hasil Belajar Kognitif dan Keterampilan Proses Sains)*", Jurnal Inovasi Pendidikan IPA, vol.2(2), pp.252 – 261, 2016.

[2] P. Kurnianto., P. Dwijayanti., & Khumaedi, "Development of Ability to Summarize and Communicate Physics Concepts Through Simple Physics Practicum Activities *(Pengembangan Kemampuan Menyimpulkan Dan Mengkomunikasikan Konsep Fisika Melalui Kegiatan Praktikum Fisika Sederhana)*", Jurnal Pendidikan Fisika Indonesia, vol.6 (1), pp.6-9, 2010.

[3] Rafidah, U., Kasli, E., & Susana, "Application of the Inquiry Learning Method with Virtual Laboratory Media (PhET) to Improve Student Learning Outcomes on the Concept of Harmonic *Vibration (Penerapan Metode Pembelajaran Inkuiri Dengan Media Laboratorium Virtual (PhET) Untuk Meningkatkan Hasil Belajar Siswa Pada Konsep Getaran Harmonis)*", Jurnal Ilmiah Pendidikan Fisika, vol.2(2), pp.226, 2017.

[4] Hapsari, A. D., Handdhika, J., & Huriawan, F., "Implementation of Guided Inquiry on Vibration, Wave and Sound Learning on Increasing Cognitive Learning Outcomes *(Implementasi Inkuiri Terbimbing pada Pembelajaran Getaran, Gelombang dan Bunyi Terhadap Peningkatan Hasil Belajar Kognitif)*", Jurnal Prosiding Seminar Nasional Fisika dan Aplikasinya, *Prosiding SNFA*, 1(1), 285-287, 2017.

[5] Ayuningtias, P., Soegiming, W. W., dan Supardi, A. I., "Development of Physics Learning Devices Using Guided Inquiry Models to Train High School Students' Science Process Skills on the Concept of Static Fluids *(Pengembangan Perangkat Pembelajaran Fisika Dengan Model Inkuiri Terbimbing Untuk Melatih Ketrampilan Proses Sains Siswa SMA Pada Konsep Fluida Statis)*, Jurnal Sains Pascasarjana Universitas Negeri Surabaya, vol.4(2), pp.636-645, 2015.

[6] Wahyudi, L. E., & Supardi, Z. A. I., "Application of the Guided Inquiry Model on the Subject of Heat to Train Science Process Skills on Learning Outcomes at SMAN 1 Sumenep *(Penerapan Model Inkuiri Terbimbing Pada Pokok Bahasan Kalor Untuk Melatih Ketrampilan Proses Sain Terhadap Hasil Belajar di SMAN 1 Sumenep*)", Jurnal Inovasi Pendidikan Fisika, vol.2(2), pp.62-65, 2013.

[7] Matthew, M.B., & Kenneth, I. O., "A Study On the Effect Og Guided Inqury Teaching Method On Students Achievement in Logic", The International Research Journal, 2(1), 133-140, 2013.

[8] Ekawati, Y., Haris, A., & Amin, B.D., "Application of Simulation Media Using PHET on Physics Learning Outcomes of Class X SMA Muhammadiyah Limbung *(Penerapan Media Simulasi Menggunakan PHET Terhadap Hasil Belajar Fisika Siswa Kelas X SMA Muhammadiyah Limbung)*", Physics Education and Technology, vol.1(3), pp.75-81, 2015.

[9] Uliyandari, M., & Lubis, E.E., "Application of the Guided Inquiry Learning Model with Volcano Teaching Aids in Science Subjects at SDN 013 North Bengkulu *(Penerapan Model Pembelajaran Inkuiri Terbimbing dengan Media Alat Peraga Gunung Berapi Pada Mata Pelajaran IPA SDN 013 Bengkulu Utara)*", Journal of Science Education, vol.4(2), pp.74-78, 2020.

[10] Dwipangestu, R., Mayub, A., & Rohadi N, "Development of Video-Based High School Physics Learning Media Design on the Concept of Sound Waves *(Pengembangan Desain Media Pembelajaran Fisika SMA Berbasis Video Pada Konsep Gelombang Bunyi)*", Jurnal Kumparan Fisika, vol.1(1), pp.48-55, 2018.

[11] Slamet, I.B., Lumbu, A., "The Use of Phet Simulation On Physics Chapter Wave and Vibratio in 3t Region", Jurnal Penelitian dan Pengapdian Kepada Masyarakat UNSIQ, vol. 8(3), pp.328-337, 2021.

[12] Abdjul, T., & Ntobou, N. E., "Application of PhET-Based Virtual Laboratory Learning Media to Student Learning Outcomes in the Wave Concept *(Penerapan Media Pembelajaran Virtual Laboratory Berbasis PhET terhadap Hasil Belajar Siswa pada Konsep Gelombang)*", Jurnal Pendidikan Fisika Taudulako, 7(3), 26-31, 2019.

[13] Prihatiningtyas, S., Prastowo, T., & Jatmiko, B., "Imlementasi Simulasi Virtual Laboratorium dan Kit Sederhana untuk Mengajarkan Keterampilan Psikomotor Siswa pada Pokok Bahasan Alat Optik *(Implementation of Virtual Laboratory Simulations and Simple Kits to Teach Students Psychomotor Skills on the Subject of Optical Instruments)*", Jurnal Pendidikan IPA Indonesia, vol.2(1), pp.18-22, 2013.

[14] Saregar, A., "Learning Introductory Quantum Physics Using PhET Simulation Media and LKM Through a Scientific Approach: The Impact on Students' Interest and Mastery of Concepts *(Pembelajaran Pengantar Fisika Kuantum Dengan Memanfaatkan Media PhET Simulation Dan LKM Melalui Pendekatan Saintifik: Dampak pada Minat dan Penguasaan Konsep Mahasiswa)*", Jurnal Ilmiah Pendidikan Fisika, vol.5(1), pp.53-60, 2016.

[15] Wicaksoni, H. T., Kurniawan, E.S., & Maftukhin, H., "Development of Resonator Teaching Aids as Alternative Learning Media on the Concept of Sound Waves for Class XII SMA *(Pengembangan Alat Peraga Resonator sebagai Alternatif Media Pembelajaran pada Konsep Gelombang Bunyi Kelas XII SMA)*", Jurnal Berkala Pendidikan Fisika, vol.3(2), pp.142-144, 20113.

[16] Mujahid, M., & Kurniawan, A., "Development of Learning Media in the Car Starter System to improve student learning outcomes at Cipta Karya Prembun Vocational School *(Pengembengan Media Pembelajaran Pada System Stater Mobil untuk meningkatkan hasil belajar siswa di SMK Cipta Karya Prembun)*", Jurnal Pendidikan teknik Otomotif, vol.1(5), pp.15-20, 2015.

[17] Haqqo, A., Prabowo, "Development of Ripple Tank Teaching Aids as Physics Learning Media on the Concept of Mechanical Waves to Improve Student Learning Outcomes *(Pengembangan Alat Peraga Ripple Tank Sebagai Media Pembelajaran Fisika Pada Konsep Gelombang Mekanik Untuk Meningkatkan Hasil Belajar Peserta Didik*)", Jurnal Pendidikan Fisika, vol.2(7), pp.341- 346, 2018.

[18] Haisy, M. C., Astra, I. M., & Handoko, E. N., "Development of Pc/Laptop Soundcard-Based Resonance and Doppler Effect Teaching Aids to Increase High School Students' Physics Learning Motivation *(Pengembangan Alat Peraga Resonansi Dan Efek Doppler Berbasis Soundcard Pc/Laptop Untuk*

Meningkatkan Motivasi Belajar Fisika Siswa SMA)", Prosiding Seminar Nasional Fisika (E-Journal), vol.5(2), pp.87-89, 2015.

[19] Sugiyono, Quantitative Qualitative Research Methods And R and D *(Metode Penelitian Kuantitatif Kualitatif Dan R dan D).* Bandung: Alfabeta, 2015.

[20] Siregar, S, Quantitative Research Methods (*Metode Penelitian Kuantitatif)*. Jakarta: Kencana, 2015.

[21] Maretasari, E., Subali, B., & Hartono, "Application of the Laboratory-Based Guided Inquiry Learning Model to Improve Student Learning Outcomes and Scientific Attitudes *(Penerapan Model Pembelajaran Inkuiri Terbimbing Berbasis Laboratorium Untuk Meningkatkan Hasil Belajar Dan Sikap Ilmiah Siswa)*", Unnes Physics Education Journal, vol.1(1), pp.27-29, 2013.

[22] Purwanto A.E., Susanti N., & Hendri M., "Comparative Study of Student Learning Outcomes Using PhET Simulations Media with Teaching Aids on the Subject of Magnetic Electricity in Class IX of SMPN 12 Tebo District *(Studi Perbandingan Hasil Belajar Siswa Menggunakan Media PhET Simulations dengan Alat Peraga Pada Pokok Bahasan Listrik Maknet Di Kelas IX SMPN 12 Kabupaten Tebo)*", Jurnal Pendidikan Fisika, vol.1(1), pp.10-16, 2016.

[23] Ernita, N., Harjono, A., & Sridan, N., "Application of the Laboratory-Based Guided Inquiry Learning Model and Its Influence on Student Physics Learning Outcomes at SMA Negeri 8 Mataram *(Penerapan Model Pembelajaran Inkuiri Terbimbing Berbasis Laboratorium Dan Pengaruhnya Terhadap Hasil Belajar Fisika Siswa SMA Negeri 8 Mataram)*", Jurnal Ilmiah Pendidikan Fisika, vol.1(2), pp.103-107, 2018.

[24] Simbolon, D. H., "The Influence of Real Experiment-Based Guided Inquiry Learning Model and Virtual Laboratory on Student Physics Learning Outcomes *(Pengaruh Model Pembelajaran Inkuiri Terbimbing Berbasis Eksperimen Riil dan Laboratorium Virtual Terhadap Hasil Belajar Fisika Siswa)*", Jurnal Pendidikan, vol.21(3), pp.299-315, 2015.

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Strengthening Creative Thinking Ability: A Project-Based Physics Assessment Instrument

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ABSTRACT

Creative thinking is one of the skills needed in education in the 21st century which requires students to think appropriately in accordance with relevant and diverse sources of information. This study examines students' creative thinking skills during project-based physics learning In the subject of work and energy. The study was conducted by 36 students in their first year of high school. It was obtained using a simple random sampling technique in one of the high schools in Kotaagung, Tanggamus. The assessment tool utilized in the study was a project assessment tool supported by a worksheet on business and energy materials. It was a valid, reliable, and useful instrument. According to the research's findings, 36 students achieved the following levels of creativity in each indicator: 1) fluency (69%); 2) flexibility (80%); 3) originality (69%); and 4) elaboration (68%).

INTISARI

Berpikir kreatif merupakan salah satu keterampilan yang dibutuhkan pada dunia pendidikan di abad 21 yang menuntut siswa dapat berpikir dengan tepat sesuai dengan sumber informasi yang relevan dan beragam. Penelitian ini bertujuan untuk menganalisis kemampuan berpikir kreatif siswa pada pembelajaran fisika berbasis proyek pada materi usaha dan energi. Penelitian dilakukan pada 36 siswa kelas X yang diperoleh dengan menggunakan teknik *simple random sampling* di salah satu SMA di Kotaagung, Tanggamus. Instrumen penilaian yang digunakan dalam penelitian menggunakan instrumen yang valid, reliabel dan praktis berupa perangkat asesmen proyek berbantuan lembar tugas pada materi usaha dan energi. Berdasarkan hasil penelitian diperoleh, pencapaian kemampuan berpikir kreatif dari 36 siswa disetiap indikatornya yaitu: 1) berpikir lancar *(fluency)* sebesar 69%; 2) berpikir luwes *(flexibility)* sebesar 80%; 3) berpikir orisinal *(originality)* sebesar 69%; 4) memperinci *(elaboration)* sebesar 68%.

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Instrumen asesmen, kemampuan berpikir kreatif, pembelajaran berbasis proyek.

A. Introduction

Creative thinking skills are a challenge in the world of education in the 21st century. These skills require students to think correctly about relevant and diverse sources of information. In line with some of the following expert opinions: According to NSTA, various 21st century skills, such as creative thinking skills, can be developed during the educational process [1]. The educational process equips students with the right way of thinking and accurate information to develop creative thinking skills [2].

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Thinking skills are processes and student behaviors that are integrated as a means of learning and comprehending learning material [3]. Related to this, the challenges of 21st century education require teachers to optimize the process of creating superior generations who are able to think creatively. Therefore, it is necessary to direct the learning process that leads to solving contextual problems. According to Yusnaeni et al., it is necessary to guide students in solving everyday problems using science [4].

The ability to think creatively is one of the skills that must be trained in order to prepare skilled students for the 21st century. The ability to think creatively is the ability to think that is trained to turn on the imagination and reveal new possibilities by opening broad perspectives to find new ideas [5]. The ability to think creatively can be interpreted as an activity to produce an idea or ideas for solving problems, as well as connecting one thing with another to find its true meaning [6]. In ref. [7], it is explained that creative thinking is a habit of the mind that is trained by paying attention to intuition, turning on imagination, expressing new possibilities, opening amazing perspectives, and generating unexpected ideas. Creative thinking is one of the important abilities that students must have in physics lessons. Through creative thinking, students are expected to be able to see physical phenomena from various perspectives. Students are also able to provide various answers to the physics problems they face. so that students have many ways to solve problems or understand physical phenomena. This has a good impact on students because they can find a way to solve physics problems that is most effective and efficient.

Creative thinking is a process that involves the elements of originality, fluency, flexibility, and elaboration. This shows that creative thinking can develop thinking skills that include insights with broad elements [8]. In ref. [7], it is explained that creative thinking is a habit of the mind that is trained by paying attention to intuition, turning on imagination, expressing new possibilities, opening amazing perspectives, and generating unexpected ideas. Another opinion explains that creative thinking is a type of thinking that leads to the acquisition of new insights, new approaches, new perspectives, or new ways of understanding something [9]. Based on this description, it can be said that the ability to think creatively is a person's ability to think from different perspectives and turn on his imagination to produce new ideas that are used to solve a problem.

Creative thinking skills as the embodiment of creative thinking, some experts reveal: (1) The ability to think differently, be sensitive to a problem, solve problems, and find unusual solutions to these problems [10]. (2) The process of creative thinking is characterized by the ability to define, analyze, and solve problems [11]. (3) There are four main components of creative thinking skills, which include fluency, flexibility, originality, and elaboration [12].

Based on the results of studies that have been conducted by researchers regarding the needs analysis carried out in one of the public high schools in Kotaagung Regency using a questionnaire, it is known that students' creative thinking abilities

are still relatively low due to the lack of availability of learning tools or media in project-based learning to measure students' creative thinking abilities in material work and energy. Paying attention to the reality at school is one of the efforts to improve students' creative thinking skills by implementing project-based learning assisted by project-based worksheets. In this study, assessment of students' creative thinking abilities was identified using an assessment instrument that included an assessment rubric. An assessment rubric can measure the quality of students' arguments or answers with clear and measurable criteria [13]. The assessment instrument used is in the form of observation sheets, assisted by the use of student assignment sheets (SAS), which help direct student activities at each PjBL steps.

B. Method

The research design used in this study is Design and Development (D&D), which prioritizes processes and products. Richey & Klein [14] define design and development methods as "the systematic study of design, development, and evaluation processes with the aim of establishing an empirical basis for the creation of new or enhanced instructional and non-instructional products, tools, and models." Design and development planning is a way to build or create knowledge based on systematic data from the application of a product.

The population in this study was made up of 11th grade science students, with a total of 216 students. The sample selection in this study was based on ref. [15]: if there are less than 100 subjects, then all of them must be sampled; if the subject is more than 100 people, then the sample can be taken at 10-15%, 20-25%, or more [15]. In this study, 16.7% of the total population was taken as a sample, namely 36 students who had studied the material physics of work and energy. This sampling technique is called simple random sampling.

The project-based learning model consists of several stages, where each phase must be completed according to a predetermined timetable. The PjBL stages are introduction, an essential question, research and writing, product creation, presentation, evaluation, and reflection [16]. Students' creative thinking abilities are measured using assessment instruments that have been prepared at the design stage and perfected at the development stage. The project-based material physics assessment instrument has been validated by experts, declared valid, reliable and and useful instrument, with several suggestions for improvement. The instrument compiled is in the form of an observation sheet containing descriptions of activities that are in accordance with indicators of scientific literacy and creative thinking of students with PjBL learning stages. Project-based learning activities are carried out with the help of Student Assignment Sheets (SAS) by considering activities during the learning process and student answers in answering questions on SAS.

Guidelines for scoring instruments for assessing students' abilities and creative thinking are carried out by changing the raw score into a percentage value by using the formula 1:

$$S = \frac{\sum X}{\sum M} 100\% \quad (1)$$

Descriptions:

S : Final Score

$\sum X$: Total score obtained by students in the assessment

$\sum M$: Total maximum score for each statement item that can be obtained by students in the assessment The total score for each statement item in this instrument is the number of items multiplied by the maximum score for each item

Then an interpretation of the assessment of students' creative thinking abilities was carried out with a scale criterion of 0–100% [17] as shown in Table 1.

Table 1. Criteria for Assessment of Creative Thinking Ability

Percentage (%)	Criteria
81 - 100	Very Good (A)
61 - 80	Good (B)
41 - 60	Adequate (C)
21 - 40	Bad (D)
< 21	Very bad (E)

C. Result and Discussion

Students' creative thinking abilities in project-based learning on work and energy materials are measured and assessed with the help of student assignment sheets (LTS) so that students' scientific literacy and numeracy skills are well honed. The results of this study obtained quantitative data in the form of students' achievements in scientific literacy and creative thinking integrated with the PjBL stage. Based on the results of the assessment using the assessment instrument for students' scientific literacy and creative thinking skills, it can be seen in Figure 1.

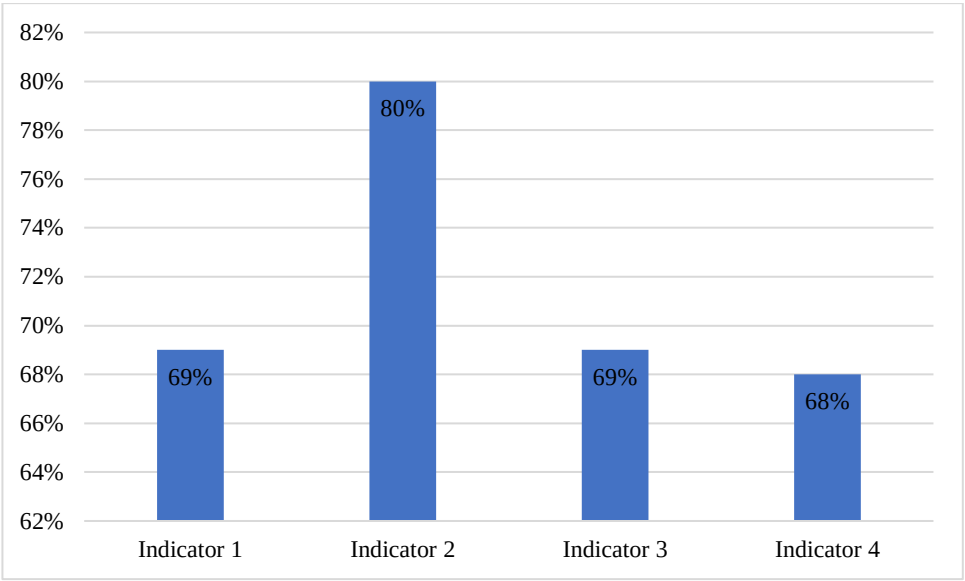


Figure 1. Achievement of Each Indicator of Creative Thinking Skills

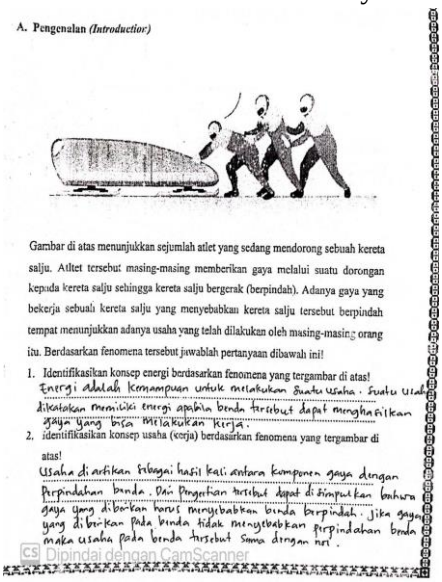
Based on Figure 1, the average score for the achievement of indicators for the ability to think creatively is obtained from 36 students for each indicator, namely: 1) thinking fluently (fluency) of 69%; 2) thinking flexibly (flexibility) of 80%; 3) original thinking (originality) of 69%; and 4) elaboration of 68% [18]. The following is presented in Table 2, which contains the distribution of indicators for each ability based on the stages of project-based learning that researchers use.

Table 2. Distribution of Students' Science Literacy and Creative Thinking Ability

Indicators of Creative Thinking Ability	PjBL Steps
Fluency	1. Essential question 2. Research and write 3. Product creation
Flexibility	1. Introduction 2. Evaluation and reflection
Originality	1. Essential question 2. Research and write 3. Prestentation
Elaboration	1. Product creation 2. Presentation

Based on Table 2, the first distribution of creative thinking ability indicators is fluency. Fluency refers to students' ability to produce various and correct answers. Answers are said to be varied if they appear different and follow a certain pattern. Student productivity to produce various and correct answers and difficulties in solving problems will also be assessed and explored to add to the results of the description of the level of students' creative thinking abilities [18]. At the essential question activity

stage, research, writing, and product creation refer to the ability of students to produce various and correct answers. Answers are said to be varied if they appear different and follow a certain pattern. Student productivity to produce various and correct answers and difficulties in solving problems will also be assessed and explored to add to the results of the description of the level of students' creative thinking abilities. Figure 2 below is an example of student work that illustrates student productivity in producing various and correct answers as a manifestation of fluency.


A. Pengenalan *(Introductior)*

Gambar di atas menunjukkan sejumlah atlet yang sedang mendorong sebuah kereta salju. Atltet tersebut masing-masing memberikan gaya melalui suatu dorongan kepada kereta salju sehingga kereta salju bergerak (berpindah). Adanya gaya yang bekerja sebuah kereta salju yang menyebabkan kereta salju tersebut berpindah tempat menunjukkan adanya usaha yang telah dilakukan oleh masing-masing orang itu. Berdasarkan fenomena tersebut jiwablah pertanyaan dibawah ini!

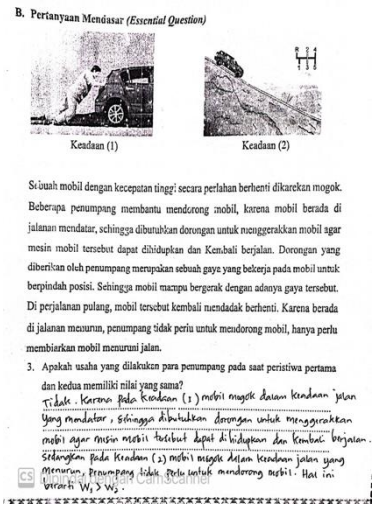
1. Identifikasikan konsep energi berdasarkan fenomena yang tergambar di atas!
   Energi adalah kemampuan untuk melakukan suatu usaha. Suatu Utah dikatakan memiliki energi apabila benda tersebut dapat menghasilkan gaya yang bisa melakukan kerja.
2. identifikasikan konsep usaha (kerja) berdasarkan fenomena yang tergambar di atas!
   Usaha di artikan sebagai hasil kali antara komponen gaya dengan perpindahan benda. Dari pengertian tersebut dapat di simpulkan bahwa gaya yang diberikan harus menyebabkan benda berpindah. Jika gaya yang diberikan pada benda tidak menyebabkan perpindahan benda maka usaha pada benda tersebut sama dengan nol.

Figure 2. Examples of students' work to think fluently (fluency)

Figure 2 represents students' ability to think creatively with indicators of fluency; previously, students were given the problems contained in the questions, which directed students to be able to identify energy concepts based on phenomena. In this case, students have succeeded in producing various and correct answers. The problems presented in Figure 2 require students to find concepts by utilizing their curiosity. Conceptual statements that were successfully built by students were "Energy is the ability to do business," while statements that describe students' curiosity were built with the statement "that an object is said to have energy when the object is able to produce a force that can do work." The second statement produced by students illustrates the number of ideas students have, which is represented by reinforcing the answers to the first statement. The second statement also describes the ability to think fluently by thinking of more than one answer. This means that at this stage, the demands of students to collect information or data to solve the problems they face have been successfully carried out using alternative problem-solving ideas supported by the knowledge and experience they have. Individuals now try to explore possible paths to solve these problems. In line with the opinions of several experts, (1) "creative thinking" means thinking in different directions and obtaining unique answers that are different but correct [19]. (2) These thinking skills are a process and

student behavior that work together to learn and comprehend the content of learning material [20]. And (3) students' ability to specify answers is an indicator of detailed thinking, as is the enthusiasm of students making two different statements based on problems [21].

The second indicator of the ability to think creatively is flexible thinking. That refers to the ability of students to generate various kinds of ideas with different approaches to solving problems.


B. Pertanyaan Mendasar *(Essential Question)*

Keadaan (1) Keadaan (2)

Sebuah mobil dengan kecepatan tinggi secara perlahan berhenti dikarekan mogok. Beberapa penumpang membantu mendorong mobil, karena mobil berada di jalanan mendatar, sehingga dibutuhkan dorongan untuk menggerakkan mobil agar mesin mobil tersebut dapat dihidupkan dan kembali berjalan. Dorongan yang diberikan oleh penumpang merupakan sebuah gaya yang bekerja pada mobil untuk berpindah posisi. Sehingga mobil mampu bergerak dengan adanya gaya tersebut. Di perjalanan pulang, mobil tersebut kembali mendadak berhenti. Karena berada di jalanan menurun, penumpang tidak perlu untuk mendorong mobil, hanya perlu membiarkan mobil menuruni jalan.

3. Apakah usaha yang dilakukan para penumpang pada saat peristiwa pertama dan kedua memiliki nilai yang sama?
   Tidak. Karena pada keadaan (1) mobil mogok dalam keadaan jalan yang mendatar, sehingga dibutuhkan dorongan untuk menggerakkan mobil agar mesin mobil tersebut dapat dihidupkan dan kembali berjalan. Sedangkan pada keadaan (2) mobil mogok dalam keadaan jalan yang menurun, penumpang tidak perlu untuk mendorong mobil. Hal ini berarti $W_1 > W_2$.

Figure 3. Examples of students' work to think flexibly (flexibility)

Figure 3 represents an example of student work for indicators of creative thinking skills to think flexibly (flexibility). The statement of questions presented in Figure 3 refers to the ability of students to generate various ideas with different approaches to solving problems. Students are expected to be able to explain every method used to solve the problem. Student productivity in changing the point of view of completion and the level of difficulty of students in solving problems will also be assessed and explored to add to the description of the results of the level of students' creative thinking ability [15].

Figure 3 presents students with scientific phenomena in the matter of work and energy, and then students are asked to identify the concepts of energy and work based on the phenomena depicted. In this stage, students need to capture a number of key or essential concepts to be able to understand certain natural phenomena and changes that occur as a result of human activities [22]. Students are presented with two phenomena at the fundamental question stage (essential question), namely circumstances (1) and circumstances (2). Students are asked to answer basic questions related to the phenomena presented, and they are also asked to interpret business relationships and energy changes based on the phenomena described. This is so that students are able to apply scientific knowledge to a situation, describe or interpret phenomena, and predict changes by identifying appropriate descriptions, explanations, and predictions [23]. At the presentation stage, students make PPTs as

presentation material for the results of simple teaching aids for work and energy, which they then present. The following is the result of student work with correct answers.

The third indicator of the ability to think creatively is originality. refers to the ability of students to give answers that are unusual, different from the others, and have the correct value. Students are expected to solve problems with their own thinking. The originality of students' answers will be assessed and further explored to measure the level of students' creative thinking ability [15]. At this stage of the activity, students give unusual answers that are different from the ones given by others and have a true value, meaning that students are expected to solve the problem with their own thinking.

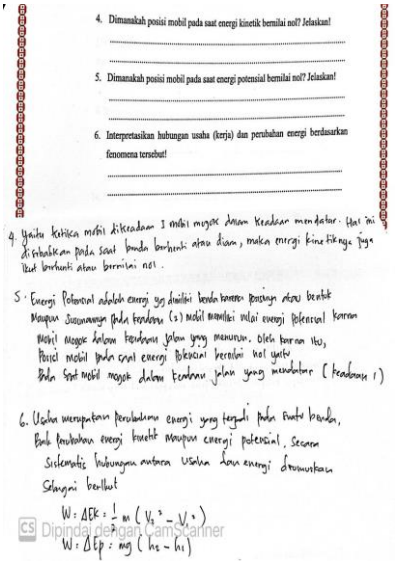
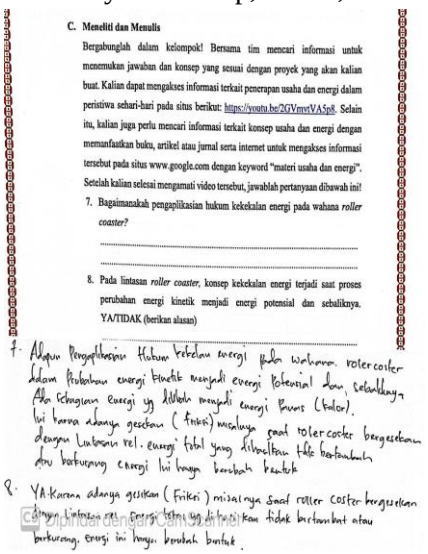


Figure 4. Examples of students' original work (originality)

Figure 4 presents an example of students' ability to elaborate by expressing new ideas and ideas that can simplify complex problems. This means that students have met the indicators of creative thinking, namely original thinking. It can be further explained that the statement in Figure 4 is able to motivate students to be involved in carrying out problem-solving activities, namely the ability to come up with unique ideas or the ability to come up with original ideas. In line with the opinion of Amtiningsih et al. [22] that the ability to think originally does require the development of aspects of fluency and flexibility first, if these two aspects have not been fulfilled, it will be difficult to achieve students' original thinking skills [24]. At this stage of activity, students are presented with a link related to the application of work and energy in daily events. Students are expected to be able to find information related to the concept of work and energy by utilizing books, articles, or journals, as well as the internet, to access this information.

The fourth indicator of creative thinking ability is elaboration. refers to the ability of students to develop, add to, and enrich an idea. Students are encouraged to add

additional information or information to clarify their answers. Productivity in providing additional information will be assessed and further explored to measure the level of students' creative thinking skills [15]. The product creation and presentation stages refer to the students' ability to develop, add to, and enrich an idea.



C. Menelitl dan Menulis

Bergabunglah dalam kelompok! Bersama tim mencari informasi untuk menemukan jawaban dan konsep yang sesuai dengan proyek yang akan kalian buat. Kalian dapat mengakses informasi terkait penerapan usaha dan energi dalam peristiwa sehari-hari pada situs berikut: https://youtu.be/2GVmvtVA5p8. Selain itu, kalian juga perlu mencari informasi terkait konsep usaha dan energi dengan memanfaatkan buku, artikel atau jurnal serta internet untuk mengakses informasi tersebut pada situs www.google.com dengan keyword "materi usaha dan energi". Setelah kalian selesai mengamati video tersebut, jawablah pertanyaan dibawah ini!

7. Bagaimanakah pengaplikasian hukum kekekalan energi pada wahana *roller coaster*?

.....

.....

8. Pada lintasan *roller coaster*, konsep kekekalan energi terjadi saat proses perubahan energi kinetik menjadi energi potensial dan sebaliknya. YA/TIDAK (berikan alasan)

.....

7. Adapun Pengaplikasian Hukum kekekalan energi pada wahana roler coster dalam Perubahan energi Kinetik menjadi energi Potensial dan sebaliknya. Ada sebagian energi yg diubah menjadi energi Panas (kalor). Ini karena adanya gesekan (friksi) misalnya saat roler coster bergerakan dengan lintasan rel. energi total yang dihasilkan tdk bertambah atau berkurang energi ini hanya berubah bentuk

8. YA Karena adanya gesekan (Friksi) misalnya saat roller coster bergerakan dengan lintasan rel. Energi total yg dihasilkan tidak bertambah atau berkurang. Energi ini hanya berubah bentuk.

Figure 5. Examples of students' work thinking in detail (elaboration)

Figure 5 represents a continuous process of solving problems with reflective thinking. This is intended to encourage students to be able to identify and solve problems in other contexts based on what they have learned [22], as in the question at this stage, "How to apply the law of conservation of energy to roller coaster rides?" "As for the application of the law of conservation of energy on roller coaster rides, there is some energy that turns into heat energy (heat), this is due to friction, for example when the roller coaster rubs against the rail track. The total energy that is produced does not change or decrease; this energy only changes form," the students responded. Statements expressed by students are based on their concepts and understanding of previous learning experiences. In addition, the statements produced by students in Figure 5 illustrate that students already have the ability to enrich and develop an idea.

D. Conclusion

Based on the results of the research and discussion, it can be concluded that the assessment instrument developed is valid and reliable for use in trials. The use of assessment instruments in project-based learning to measure students' scientific literacy and creative thinking abilities on business and energy materials with the help of student assignment sheets (LTS) can have a positive influence on students' scientific literacy skills and creative thinking skills with the following percentages: 2) thinking flexibly (flexibility) by 80%; 3) original thinking (originality) by 69%; and 4) detailing (elaboration) by 68%. This research is not without shortcomings. The

shortcomings in this study are that researchers only focus on scientific literacy skills and creative thinking. In addition, researchers only conduct research by implementing the 2013 curriculum. Researchers provide suggestions for further research to be carried out in assessing the abilities needed in the 21st century and using the latest curriculum.

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References

[1] National Science Teacher Association, Quality Science Education and 21st-Century Skills. [Online] (http://www.nsta.org/about/positions/21stcentury.aspx, accessed Februari, 28 2016), 2011.

[2] Bacanli, H., Dombayci, M. A., Demir, M., & Tarhan, S.,"Quadruple thinking: Creative thinking. Procedia-Social and Behavioral Sciences, vol.12, pp.536-544, 2011.

[3] Beers, S.. 21st Century Skills : Preparing Students For Their Future.[Online] http://www.yinghuaaca demy. org/wpcontent/uploads/2014/10/21st_century_skills.pdf accessed Oktober, 4 2015), 2011.

[4] Yusnaeni et al., "Creative Thinking of Low Academic Student Undergoing Search Solve Create and Share Learning Integrated with Metacognitive Strategy", International Journal of Instruction, vol.10(2), pp.245-262, 2017.

[5] Suripah, S., dan Sthephani, A., "Students' Mathematical Creative Thinking Ability in Solving Roots of Complex Equations Based on Academic Ability Level *(Kemampuan Berpikir Kreatif Matematis Mahasiswa dalam Menyelesaikan Akar Pangkat Persamaan Kompleks Berdasarkan Tingkat Kemampuan Akademik)*", PYTHAGORAS: Jurnal Pendidikan Matematika, vol.12(2), pp.149-160, 2017.

[6] Marliani, N., "Improving Students' Mathematical Creative Thinking Skills Through the Missouri Mathematics Project (MMP) Learning Model *(Peningkatan Kemampuan Berpikir Kreatif Matematis Siswa Melalui Model Pembelajaran Missouri Mathematics Project (MMP))*", Jurnal Formatif, vol.5(1), pp.14-25, 2015.

[7] Johnson, S., Where Good Ideas Come From. New York: Riverhead books, 2010.

[8] Susanto, Theory of Learning and Learning in Elementary Schools *(Teori Belajar dan Pembelajaran di Sekolah Dasar)*. Jakarta: Kencana Prenadamedia Group, 2013.

[9] Bacanli, H., Dombayci, M. A., Demir, M., & Tarhan, S., "Quadruple thinking: Creative thinking. Procedia-Social and Behavioral Sciences", vol.12, pp.536-544, 2011.
[10] Bayindir, N., & Inan, H. Z., "Theory into practice: Examination of teacher practices in supporting children's creativity and creative thinking". Ozean Journal of Social Science, vol.1(1), 2008.
[11] Alghafri, A. S. R., & Ismail, H. N. B., "The Effects of Integrating Creative and Critical Thinking on Schools Students' Thinking", International Journal of Social Science and Humanity, vol.4(6), pp.518, 2014.
[12] Richey R.C., & Klein J.D., Design and Development Research. In: Spector J., Merrill M., Elen J., Bishop M. (eds) Handbook of Research on Educational Communications and Technology. Springer, New York, NY, 2014
[13] Cameron, S., and Carolyn C., Project-Based Learning Task for Common Core State Standards, Grade 6-8. United State of America: Mark Twain Media, Inc, 2014.
[14] Arikunto, S dan Jabar, Educational Program Evaluation *(Evaluasi Program Pendidikan)*. Revised Edition. Jakarta: Bumi Aksara, 2007.
[15] Munandar, Utami, Pengembangan Kreativitas Anak Berbakat. Jakarta:Rineka Cipta, 2012.
[16] Slameto, Learning and the factors that influence it *(Belajar dan faktor-faktor yang mempengaruhinya)*. Jakarta : PT Rineka Cipta, 2003.
[17] Beers, S., 21st Century Skills : Preparing Students For Their Future.[Online]http://www.yinghuaaca demy. org/wpcontent/uploads/2014/10/ 21st_century_skills.pdf accessed by October, 4 2015), 2011.
[18] Wulandari, "Problem based learning to improve creative thinking skills and students' mastery of concepts in buffer solution material *(Problem based learning untuk meningkatkan keterampilan berpikir kreatif dan penguasaan konsep siswa pada materi larutan penyangga)*", Jurnal Pengajaran MIPA, vo.l.16(2), October 2011, pp.116-12, 2011.
[19] Rustaman, et al., Biology Teaching and Learning Strategies *(Strategi Belajar Mengajar Biologi)*. Bandung: Universitas Pendidikan Indonesia, 2004.
[20] Amtiningsih, S., Dwiastuti, S., dan Sari, D. P., "Increasing Creative Thinking Ability through the Application of Guided Inquiry combined with Brainstorming on Water Pollution Material *(Peningkatan Kemampuan Berpikir Kreatif melalui Penerapan Guided Inquiry dipadu Brainstorming pada Materi Pencemaran Air)"*, Proceeding Biology Education Conference, vol.13, No 1, pp. 868– 872, 2016.
[21] Odja, A.B. dan Payu, C.S., Analisis Kemampuan Awal Literasi Sains Siswa pada Konsep IPA. Prosiding Seminar Nasional Kimia. Surabaya: Jurusan Kimia FMIPA Universitas Negeri Surabaya, 2014.

[22] Widiansyah & Saputra, "Analysis of Reflective Learning Models in Improving Student Learning Outcomes in the Pancasila Education Course (Analisis Model Pembelajaran Reflektif dalam Meningkatkan Hasil Belajar Mahasiswa Pada Mata Kuliah Pendidikan Pancasila", Cakrawala, vol.21(1), Maret 2021.
[23] Yasir, M., Ibrahim, M., & Widodo, W., "Development of Metacognitive-Based Biology Learning Devices to Train Reflective Thinking Skills for High School Students. MIPA Teaching Journal *(Pengembangan Perangkat Pembelajaran Biologi Berbasis Metakognitif untuk Melatihkan Keterampilan Berpikir Reflektif Siswa SMA)*", Jurnal Pengajaran MIPA, vol.20(2), pp.163-176, 2015.
[24] Haerudin, "Application of the SAVI Method with an Inductive Approach and Increased Mathematical Creative Thinking *(Penerapan Metode SAVI Dengan Pendekatan Induktif dan Peningkatan Berpikir Kreatif Matematis)*", Prosiding Seminar Nasional Pendidikan Matematika STKIP Siliwangi Bandung, vol.1, pp. 287- 291, 2011.

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Analysis of Student's Misconceptions in Static and Dynamic Electricity Physics Using the Three Tier Test

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ABSTRACT

Physics is one of the subjects that is considered difficult, this assumption is reinforced by students who experience misconceptions, some even do not understand the concept. This study aims to find out students' misconceptions about static electricity and dynamic electricity. The research method is qualitative, with research subjects consisting of 20 students from class XII. The test instrument used consisted of 10 static and dynamic electricity questions self-made with content validation results of 0.96, empirical validity of 1.01, and reliability of 0.8 using the three tier test method. The data collection techniques used in the form of tests. The results of the study showed that 33.5% of students experienced misconceptions, the value was categorized as moderate. Meanwhile, 29.5% did not understand the concept and 35% understood the concept. Although the level of misconception is categorized as moderate, it still has to be an evaluation.

INTISARI

Fisika merupakan salah satu mata pelajaran yang dianggap sulit, anggapan tersebut diperkuat dengan siswa yang mengalami miskonsepsi, bahkan terdapat pula yang tidak memahami konsep. Penelitian ini bertujuan mengetahui miskonsepsi siswa pada materi listrik statis dan dinamis. Metode penelitian adalah kualitatif, dengan subyek penelitian terdiri dari siswa kelas XII berjumlah 20 siswa. Instrumen tes yang digunakan terdiri dari 10 soal listrik statis dan dinamis yang dibuat sendiri dengan hasil validasi isi 0,96, validitas empiris 1,01, dan reliabilitas 0,8 dengan metode *three tier test*. Adapun teknik pengumpulan data yang digunakan berupa tes. Hasil penelitian terdapat 33,5 % siswa mengalami miskonsepsi, nilai tersebut dikategorikan sedang. Sedangkan siswa yang tidak memahami konsep sebesar 29,5 % dan siswa yang memahami konsep 35 %. Meskipun tingkat miskonsepsi dikategorikan sedang, namun tetap harus menjadi evaluasi untuk pembelajaran.

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A. Introduction

The quality of education is related to quality because the central point in the teaching and learning process of students is the students. Students are expected to gain as much knowledge and insight as possible by learning. The low understanding of students in understanding a lesson is indicated by student achievement that is not in line with expectations. The incompatibility of learning

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outcomes with what is expected is a dilemma that will refer to the learning system [1].

Physics is a science that is closely related to natural phenomena. As a science, physics has various kinds of concepts. Many students have difficulty understanding physics concepts [2][3]. Physics is a subject that is regarded as challenging. Despite the fact that it is a crucial subject, some students lack interest for a variety of reasons. This may contribute to children developing misconceptions. Alamsyah and Sudrajat [4] define misconceptions as errors in linking one concept with others, between new concepts and concepts that already exist in students' thoughts, which leads to the formation of incorrect concepts that are at odds with expert conceptions.

Misconceptions often occur in physics subjects, especially static electricity in this study. While students' understanding of concepts is a goal in learning physics [5]. According to Malikha [6] defines misconception as a strong understanding of a concept, but not in accordance with the concept presented by the expert. The cause of misconceptions is not only from the students themselves, it can be other factors such as the teacher's delivery, the media, or the teaching materials used

Students' understanding of physics does not entirely prepare them to solve challenges in the actual world [7]. The results of the 2015 PISA (Program for International Student Assessment) review, in which Indonesian students' physics success score was rated 69th out of 76 nations, provide evidence of this. The PISA physics component measures students' capacity to recognize issues with comprehending natural facts, occurrences, and alterations in the environment.

According to Pujayanto [8] low student knowledge and misconceptions are to blame for Indonesian students' continued lack of physics proficiency. A three-tiered diagnostic test can be used to identify student misconceptions. The three-tier diagnostic test consists of questions with three alternative answers, including the degree of confidence in selecting an answer, the reason for selecting an answer, and the degree of confidence in the explanation. It is a three-level multiple-choice test. Misconceptions can cause new knowledge not to be properly integrated into students' cognitive structures [9]. If new concepts are transferred into students' cognitive structures and mixed with misconceptions, it will result in wrong understanding [10]. Didik and Aulia [11] define a three-tier diagnostic test as a three-level test with the first level (one tier) of ordinary multiple choice, the second level (two tier) of multiple choice reasons for choosing the first level, and the level when (three tier), namely the choice of students' beliefs based on the answers in the first and second levels.

Eryilmaz and Surmeli have developed a three-tier diagnostic test instrument which is a combination of a two-tier test combined with the Certainty Response

Index (CRI) [12]. The three-tier test instrument has the advantage of being able to distinguish between misconceptions with a lack of understanding of the concept or not knowing the concept through the confidence level of the student's answers, so that it is accurate in detecting misconceptions. Three levels in the three-tier test, namely: (1) the first level asks descriptive questions, (2) the second level asks the reasons for the answers given and also inserts options in the form of blanks (free responses), to find out whether students experience new misconceptions or misconceptions which was not found in the previous literature, and (3) the third level asks students' confidence in answering questions [12].

Understanding the concept with correct answers (true or false), not understanding the concept with correct or wrong (true or false), or wrong (true or false) unsure answers, and misconceptions with right or wrong (true or false) sure answers are divided into three categories. Respondents in this study were 20 class XII high school students. Through the answers from the tests that have been answered by respondents to the misconception questions that have been distributed, the percentage of students' misconceptions about static and dynamic electricity can be obtained.

B. Method

This research is qualitative study. This study used a sample of 20 class XII high school students. The test carried out was a three-tier diagnostic test, and the research questionnaire consisted of 10 questions about static and dynamic electricity misconceptions. The static and dynamic electricity questions tested were self-made with content validation results of 0.96, empirical validity of 1.01, and reliability of 0.8 using the three tier test method. The data collection techniques used in the form of tests.

The type of research used in this research is descriptive research with a qualitative approach. The research design in this study was prepared according to the variables studied. This study aims to identify students' misconceptions about physics on the subject of static and dynamic electricity using a three-tier diagnostic test as the instrument. The use of a three-tier diagnostic test is expected to be able to detect students' Physics misconceptions well. Misconceptions can be identified by providing multiple choice test questions that are adapted to the subject matter of static and dynamic electricity in high school. In the use of a three-tier diagnostic test, multiple choice questions have three levels of answers. For the first level, namely in the form of multiple choice questions in general, the second level is in the form of students' reasons for choosing answers at the first level, and the third level is in the form of students' confidence in the answers of the two previous levels. This study uses a three-tier diagnostic test with open reasons, because it is expected that the reasons given by students are an understanding that is already owned and accepted during the learning process for each student. In addition, there

is confidence, namely to find out the stability of students towards their understanding. Identification of Physics misconceptions uses a three-tier diagnostic test to classify students who understand concepts, misconceptions, and do not understand concepts. Because the mistakes of students in giving answers are not all classified as misconceptions, this can happen because students do not understand the concept. To analyze the data that has been collected, the researcher takes the following steps: (1) Analyzes the students' answers between the multiple choice results, the reasons and the students' beliefs according to the categories of understanding levels in the three-tier diagnostic test. (2) Grouping the categories of students' answers into understanding, lack of understanding, and misconceptions. (3) Calculate the percentage of misconceptions experienced by students in each item. (4) Make conclusions from the data obtained in the form of a profile of misconceptions and the percentage of misconceptions.

$$P = \frac{M}{N}\, x\, 100\% \qquad (1)$$

Description:

P : Percentage of misconceptions

M : the number of students who have misconceptions

N : the total number of students

C. Result and Discussion

This research was conducted to determine the percentage of misconceptions that occur in static electricity material among high school students using a three-tier test consisting of 10 questions. The results of the answers obtained were grouped into three, namely understanding the concept (PK), not understanding the concept (TPK), and misconceptions (M), as can be seen in table 1.

Table 1. Results of Respondents' Answers

Answer	Reason	Belief	Category	Code
True	True	Not Sure	understand the concept	UC
True	False	Not Sure	don't understand the concept	DUC
False	True	Not Sure	don't understand the concept	DUC
False	False	Not Sure	don't understand the concept	DUC
True	False	Sure	misconception	M
False	True	Sure	misconception	M
False	False	Sure	misconception	M

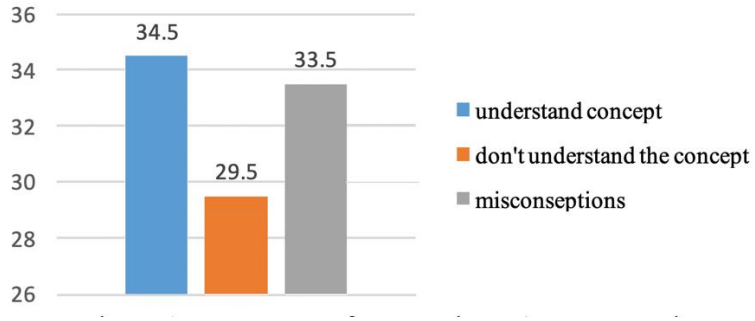

Figure 1. Percentage of Respondents Answer Results

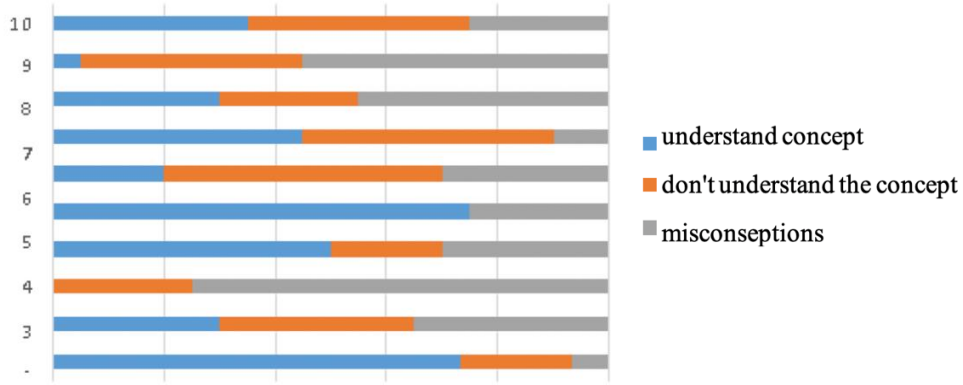

Figure 2. Results of Misconceptions for Each Question by Respondents

There are 2 student answer sheets in Figure 3, then the answers are processed according to the provisions in Table 1 so that the level of understanding is known.

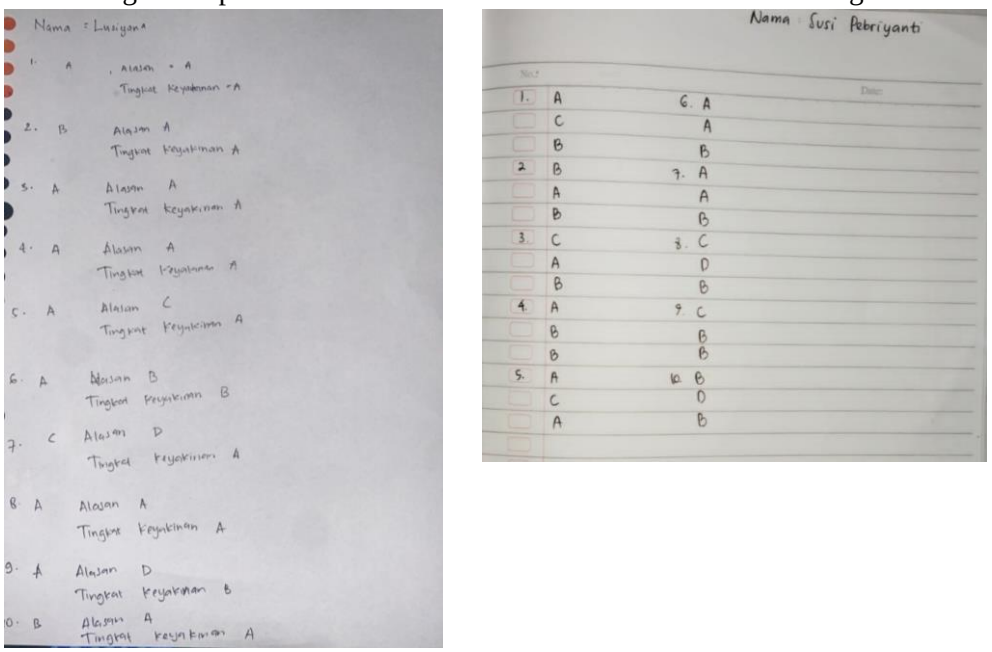

Figure 3. Student Answer Sheet

A total of 20 students participated in the observation of the concept of static and dynamic electricity. The results obtained for the students' understanding as a whole are written in Figure 3. The percentage of understanding the concept of 34.5% is included in the medium category; the presentation of not understanding the concept is 29.30%, which is categorized as low; and the percentage of misconceptions is 33.5%, which is included in the medium category. One of the factors causing misconceptions in students is the lack of variation in the methods used, which causes them to become bored. For example, when the teacher explains in front, students sit and pay attention. Over time, students will feel bored, until finally they become passive. Learning should be carried out as interestingly as possible, so that two-way communication is created and raises curiosity in students. Misconceptions among students, especially about static electricity material, also occur because this material is classified as abstract, especially in parallel electric circuits and electric charges that occur in the application of static electricity. Misunderstandings about concepts need to be straightened out so as not to hinder students in learning, although sometimes students who experience misconceptions find it more difficult to accept the correct concept. According to Suparno (2005) students who experience misconceptions will tend to defend their opinions, because these concepts are understood by students, students can also explain the concept. So the teacher needs to provide opportunities for students to convey concepts that they understand, so that they can find out whether they are in accordance with concepts or misconceptions.

Details of the level of understanding of the concept for each item can be seen in Figure 2, which shows in more detail the percentages of understanding the questions, not understanding the questions, and misconceptions on each question.

The first question contains the question of what happens if the positive and negative charges are brought closer together. All respondents managed to answer correctly. Even so, the level of student understanding only reached 55%; 15% did not understand the concept, and 5% of the misconceptions were categorized as low. This is evidenced by the percentage results obtained.

In the second question, students were asked to analyze the distance between the two loads, which was extended twice from the original distance. In this second question, the differences between understanding the concept, not understanding the concept, and misconceptions were almost even, with successive values of 30%, 35%, and 35%. The level of misconceptions in this question is categorized as moderate. This is evidenced by the percentage results, which are almost the same size.

The third question concerns the charges that occur on silk and glass after they are rubbed. The level of understanding of the concept of 0% is low; no students understand this concept. Conversely, as many as 75% of students

experienced misconceptions and answered that the electrons on silk cloth increased and the electrons on glass decreased; some students also answered that the electrons on glass and silk cloth increased. The remaining 25% do not understand the concept.

The fourth question is regarding the location of the strongest magnetic field. Misconceptions students answer the point between the two poles with a percentage of 30%. while understanding the concept of 50% and not understanding the concept of 20%.

The fifth question concerns the events that occur when a comb is rubbed against dry hair, then the comb is brought close to a piece of paper. The result is that 75% of students succeed in understanding this concept. While the misconception is 25% of the answer, there is a strong electric force, and after the two objects are rubbed together, they produce a magnetic field.

In the sixth problem, there was an event in which two blocks were rubbed, one of which experienced an excess of electrons; the question is the charge on one of the objects that had an excess of electrons before rubbing. Half of the students did not understand the concept here, 20% understood the concept, and the remaining 30% had misconceptions about the answer: that the object before rubbing had few electrons so that after rubbing it had excess electrons.

The seventh question is about a series of lights. The level of misconceptions on this question is in the low category, with a percentage of 10%. Students who understand and do not understand the concept of balance are separated by 45%.

The eighth problem is about the effect of two blocks rubbing against an electric charge. Students who have misconceptions respond that the proton charge moves and that if one object is overloaded, the excess will move; this misconception accounts for 45% of the total. Other students understand the concept to a lesser extent (30%) but not at all (25%).

A picture of an electric circuit with the switch closed is shown in the ninth question.The result is that 55% of students experience misconceptions, 40% do not understand the concept, and only 5% understand it. From this percentage, it can be concluded that the questions presented are in the difficult category.

You inquired about the quality of the lamp flame at various voltages in your previous question. Some students believed that the lamp would continue to glow brightly at different voltages. Miscoception is categorized as low with a percentage of 25%; it understands the concept of 35% but does not understand the concept of 40%.

D. Conclusion

The level of misconceptions about static and dynamic electricity is moderate, with a percentage of 33.5%. There is a high level of misconception about the charge state that occurs after a silk cloth is rubbed with glass. While the

category of misconceptions is found in the events that occur when positive and negative charges are brought closer, where the magnetic field is strongest, and in a series electric circuit, The rest are categorized as low misconceptions. Misconceptions occur because the learning methods used are not appropriate and students do not understand the material well.

Based on that misconception have found, a strategy learning needs to be designed for overcome these misconceptions students do not experience it anymore.

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References

[1] Suryawan, IPA., Santyasa IW., & Sudarma IK., "The Influence of the Discovery-Inquiry Learning Method on the Reduction of Misconceptions and Physics Learning Achievement *(Pengaruh Metode Pembelajaran Discovery-Inquiry terhadap Reduksi Miskonsepsi dan Prestasi Belajar Fisika)*". Jurnal Teknologi Pembelajaran Indonesia, vol.10(1), pp.25-34, 2020.

[2] Aritonang, K. T., "Interest and Motivation in Improving Student Learning Outcomes *(Minat dan Motivasi dalam Meningkatkan Hasil Belajar Siswa)*", Jurnal Pendidikan Penabur, no.10, June 2008.

[3] Wijayanti P.I. et.al., "Exploration of Student Learning Difficulties on the Subject of Light and Efforts to Increase Learning Outcomes Through Guided Inquiry Learning *(Eksplorasi Kesulitan Belajar Siswa Pada Pokok Bahasan Cahaya dan Upaya Peningkatan Hasil Belajar Melalui Pembelajaran Inkuiri Terbimbing)*", Jurnal Pendidikan Fisika Indonesia, vol. 6, pp.1–5, 2010.

[4] Alamsyah, S. & Sudrajat, Learning Learning in Elementary Schools *(Belajar Pembelajaran di Sekolah Dasar)*. Daerah Istimewa Yogyakarta: Deepublish, 2021.

[5] Suparno, P., Misconceptions and Concept Changes in Physics Education *(Miskonsepi dan Perubahan Konsep dalam Pendidikan Fisika)*. Jakarta: PT Grasindo, 2007.

[6] Malikha, Z. & Amir, M.F., "Misconception Analysis of Class V-B Students Min Buduran Sidoarjo on Fractions Material in View of Mathematical Ability *(Analisis Miskonsepsi Siswa Kelas V-B Min Buduran Sidoarjo pada Materi Pecahan Ditinjau dari Kemampuan Matematika)*", Jurnal Mathematics Education, vol. 2(1), pp.75-81, 2018.

[7] Wisudawati, A.W., The Science Learning Methodology is adapted to the 2013 Curriculum Learning *(Metodologi Pembelajaran IPA disesuaikan dengan Pembelajaran Kurikulum 2013)*. Jakarta: Bumi Aksara, 2017.

[8] Pujayanto, "Misconceptions of Science (Physics) in Elementary School Teachers. Journal of Materials and Learning Physics *(Miskonsepi IPA (Fisika)*

pada Guru SD)", Jurnal Materi dan Pembelajaran Fisika, vol.1(1), pp.22 – 24, 2011.
[9] Costu, B., Ayas, A. & Niaz, M., "Promoting Conceptual Change in First Year Student's Understanding of Evaporation", Chemistry Education Research and Practice, vol.11, pp.5-16, 2010.
[10] Mosik, P.M., "Efforts to Reduce the Occurrence of Physics Misconceptions through Learning with a Cognitive Conflict Approach *(Usaha Mengurangi Terjadinya Miskonsepsi Fisika melalui Pembelajaran dengan Pendekatan Konflik Kognitif)*", Jurnal Pendidikan Fisika Indonesia, vol. 6, pp.98-103, July 2010.
[11] Didik, L. A., & Aulia, F., "Analysis of the level of understanding and misconceptions on static electricity material for physics tadris students using the 3-tier multiple choices diagnostic method *(Analisa tingkat pemahaman dan miskonsepsi pada materi listrik statis mahasiswa tadris fisika menggunakan metode 3-tier muliple choices diagnostic)*". Jurnal Phenomenon, vol.9(1), pp.99-112, 2019.
[12] Pesman, Haki, Development of a three-tier test to asses ninth grade Student misconceptions about simple electric circuits. Master Thesis in Middle East Technical University, 2005.

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