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The Validation of a Video-based Learning Instrument (Tracker) on the Material of Free-Falling Motion with the PBL Model

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ABSTRACT

This study aims to describe the validity of the VBL learning device (Tracker) on GJB material through the PBL model. This research is research and development, but this article is only at the validity stage. The research instrument used is a validation sheet. The resulting learning tools are validated by one expert. The results of the analysis show that 1) the validity of the device in terms of the validation of the RPP (Learning Implementation Plan) obtains a score of 3.65 in the valid category, the validity of the LKPD (Student Worksheets) obtains a score of 3.81 in the valid category, and the validity of the THB (Learning Outcomes Test) obtains score 4 valid theory. It was concluded that the VBL learning tool (Tracker) on GJB material through the PBL model is in the valid category so that it can be used for the next development stage.

INTISARI

Penelitian ini bertujuan untuk mendeskripsikan validitas perangkat pembelajaran VBL (Tracker) pada materi GJB melalui model PBL. Penelitian ini merupakan penelitian dan pengembangan, namun pada artikel ini hanya pada tahap validitasnya saja. Instrumen penelitian yang digunakan berupa lembar validasi. Perangkat pembelajaran yang dihasilkan divalidasi oleh satu orang pakar. Hasil analisis menujukkan bahwa 1) validitas perangkat ditinjau dari validasi RPP (Rencana Pelaksanaan Pembelajaran) memperoleh skor 3,65 berkategori valid, validitas LKPD (Lembar Kerja Peserta Didik) memperoleh skor 3,81 berkategori valid, dan validitas THB (Tes Hasil Belajar) memperoleh skor 4 berkateori valid. Disimpulkan bahwa perangkat pembelajaran VBL (Tracker) pada materi GJB melalui model PBL berkategori valid, sehingga dapat digunakan untuk tahap pengembangan selanjutnya.

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A. Introduction

The vast development of electronic fields and science and technology encourage humans to encounter the digital era. In this current 4.0 industry, all matters are sophisticated with shifts of human employment into robotic implementations. Humans must respond the advanced technological development positively. This matter also goes for the teacher candidates to use technology in education. Electronic uses could facilitate learners in understanding various concepts, especially physics concepts.

Physics refers to a science that discusses various concepts, facts, principles, laws, and natural phenomena with the implementation of scientific methods to prove. This matter goes from the real into abstract matters [1]. With the concepts of force, energy, and motion, physics could explain various natural phenomena including mechanics, terma, optical, electrical, magnetic, and various phenomena. With the implementation of scientific and mathematical methods, physics could facilitate humans to understand the basic principles. These principles regulate the universe; open new technological inventions; and advance human civilization.

The process of implementing physics requires accurate media implementation. Suyanto [2] explains that an excellent or effective learning media should cover three important aspects (within certain conditions), such as content material, media design, and effectiveness aspects. The learning media test is useful to ensure the reliability of the developed media based on the learning context. This test includes the evaluation of various aspects such as reliability, technical, information clarity, user accessibility, learning objective relevance, and learning outcome effectiveness with the media implementation. Besides that, the test covers the trial run of the representative users to gain useful feedback for further quality improvement, broad implementation, and effectiveness determination. One of the crucial physics materials is free-fall objects due to the gravitational force without considering the air friction. The implementation of relevant learning media for the material is important because of the complex concept. Thus, relying on verbal lectures is not recommended. Media such as animation or computer simulation could facilitate learners to visualize the free-falling motions. Besides that, the implementations of graphics, data tables, and relevant real cases could facilitate the learners to understand the concepts of time, distance, velocity, and acceleration of the free-falling motion and the entailing physics laws.

Various efforts of school physics learning include the implementation of accurate learning media to facilitate material delivery. The applicable learning media to share the facts and concepts of physics may include photographs, videos, and properties. These media implementations could realize a qualified learning process [3]. The media implementations could facilitate the learners' understanding while the teachers are delivering the materials.

The limited physics properties at schools become a hindrance to the experimental method in delivering the physics concepts [4]. Most properties are expensive so schools cannot afford the properties to facilitate the practices of free-falling objects. Thus, most schools teach the material conventionally. One of the efforts to measure the time of the falling object is with a stopwatch. This measurement technique makes the practice of calculating the free-falling motion not accurate because the falling objects are fast. Thus, merely relying on the human visual capability manually [5]. Measuring the time aspect manually during the practices of free-falling objects is susceptible to measurement mistakes so the obtained data are not accurate. Therefore, accurate media implementation is important to facilitate learners in learning the material. One of the applicable media for learning is the implementation of software-based media. The advancements in technology and computers, including the developed software by IT experts are excellent for example the Tracker software.

Tracker software could analyze and model the phenomena of motion and optics freely. This software is developed by Open Source Physics, OSP, with the Javascript programming language and specific design to learn physics (physlets.org). Tracker software could analyze videos in the form of video-based learning with the design of presenting actual physics phenomena in the forms of quantitative data and graphics simultaneously [6]. The tracker software facilitates learners to analyze an object's motion in a video by tracing the track in the video.

In this research, the researchers found many learners could not design the video-based learning media correctly and autonomously. Many learners did not have any interpretation of the VBL media to analyze with the tracker software. They could not do this action because the software was not familiar to the learners and had to be adjusted to the discussion contexts, such as the real physics event as the principle of the learning concept. Therefore, the capabilities of educators in developing physics learning videos are important to facilitate the understanding of complex and abstract physics concepts. Video implementations could facilitate abstract conceptual understanding because of the capability to show the acceleration, deceleration, and detail of the observed objects by learners [7]. Therefore, the integration of directive and guided learning models for learners is important to encourage the learners to find the learning concepts by designing the VBL media. The applicable learning to facilitate the learners in finding the physics concepts in daily life is - the problem-based learning model.

Arend [8] explains that a learning model with a learner-centered approach and authentic problem encourages learners to arrange personal cognition, develop personal psychomotor, and inquiry, and autonomy capabilities. A PBL model has some features of real-life problems as something to learn. The PBL model could facilitate learners to master various skills instead of the memorized information skill.

The skills may include problem-solving, critical thinking, collaborative performance, interpersonal, communication, and information-finding and management skills. This research describes the validity of the physics learning instrument about free-falling objects based on VBL (tracker) media on the PBL model.

B. Method

This research and development develops a valid VBL-based learning instrument, the Tracker on the PBL model based on the lesson plan, the worksheet, and the learning outcome test. The applied development model is the 4D model. This model consists of defining, designing, developing, and disseminating.

First, is the defining stage. This step collects information about the necessity. The collected information includes the analyses of necessity, the identification, and the cause of the learning problems about the free-falling object material. Second, the designing stage. This step designs the relevant strategy to develop the VBL learning instrument, the Tracker, on the PBL model to overcome the problems experienced by the learners. Third, is the developing stage. This step produces the required learning instrument. The developed learning plan included the lesson plan, worksheet, and learning outcome test arrangements to support the learning. The final step, the dissemination. This step disseminates the evaluation of the product validity based on the validity results and publishes the product in journals.

The product validity requires a validity test by the experts [9]. The applied research instrument was the validity sheet with systematic arrangement. The researchers collected the data with the validation process by two experts, and the supervising lecturers. The collected data from the learning instrument assessment consisted of a lesson plan, worksheet, and learning outcome test. Then, the researchers analyzed the data descriptive qualitatively to determine the validity category of the developed product. The valid category of the instrument is based on the score comparisons based on the validity criteria of the learning instruments [10].

Then, the researchers assessed the media validity based on the given aspect by involving two expert lecturers. After collecting the data, the researchers weighted each response and calculated the mean with the following formula.

$$\bar{x} = \frac{\sum X}{n} \quad (1)$$

Remarks:
$\bar{x}$ = mean
n = the total of the assessors
ΣX = each total score

The researchers categorized the learning media validity based on the following criteria [11].

Table 1. The Criteria for the Media Validity

Score	Category
0-1	Invalid
1-2	Less valid
2-3	Adequately valid
3-4	Valid

C. Result and Discussion

The experts reviewed the developed teaching materials. The results of the development were expected to be applied by the SHS learning within the material of free-falling objects. The developed teaching materials were a lesson plan, worksheet, and learning outcome test.

The Lesson Plan

A lesson plan refers to the arranged procedure to direct the teaching-learning activity in achieving the determined learning objectives. The lesson plan format should refer to the learning achievements, and indicators of competence achievements (cognition, attitude, and psychomotor). The learning objectives then elaborated on the points of the indicators. Then, the learning strategy consisted of the model, method, approach, material, learning source, and learning assessment.

The validation test of the learning instrument development was valid based on the validation sheets by the validators [12]. The validity test of the lesson plan consisted of some assessment aspects, such as school identity, lesson identity, core material, learning objective, core competence achievement indicator, media, tool, learning source, learning activity, assessment, and language. Table 2 shows the calculation of the lesson plan validation test.

Table 2. The Results of the Lesson Plan Validity

The Assessment Aspect	Results	Category
School Identity	4	Valid
Lesson plan identity	4	Valid
Core material	4	Valid
Learning objectives	4	Valid
Worksheet	3	Valid
Media, tools, and learning sources	4	Valid
		Valid
Learning Activity	3.6	Valid
assessment	3.3	Valid
Language	3	Valid

The aspect of the school identity consists of two sub-aspects: the name of the educational unit with complete writing; and the class and the semester with complete writing. The results of the expert lecturer validations obtained a mean of 4 with the category of valid. The aspect of lesson identity consists of two sub-aspects: the lesson identity with complete writing; and the core material identity with complete writing. The results of the expert lecturer validations obtained a mean of 4 with the category of valid. The aspect of core material consists of one sub-aspect, the relevant primary materials based on the applied core and basic competencies. The results of the expert lecturer validations obtained a mean of 4 with the category of valid. The aspect of the learning objective consists of two sub-aspects: the relevance with the applied basic competence; and the relevance between the learning objective formulation and the learning process and achieved results. The results of the expert lecturer validations obtained a mean of 4 with the category of valid. The aspect of the core competence achievement indicator consists of three sub-aspects: the relevance with the basic competence, the relevance with the learning objective, and the relevance between the operational verbs and the measured basic competencies. The results of the expert lecturer validations obtained a mean of 3 with the category of valid. The aspect of media, tools, and learning sources consists of two sub-aspects: the relevance with the learning material and the relevance with the basic competence. The results of the expert lecturer validations obtained a mean of 4 with the category of valid. The aspect of learning activity consists of five sub-aspects: displaying the preliminary activity, core activity, closing activity, the relevance between core competence and basic competence, the relevance between the learning objective and worksheet, the relevance of the learning model syntax, and the relevance of the time allocation. The results of the expert lecturer validations obtained a mean of 3.6 with the category of valid. The aspect of assessment consists of three sub-aspects: the relevance between the assessment procedure and the targeted objective, the question, the answer, the clear and comprehensive written notifications, and the relevance with the worksheet. The results of the expert lecturer validations obtained a mean of 3.3 with the category of valid. The aspect of language consists of two sub-aspects: the standardized Indonesian language and the implementation of non-ambiguous words. The results of the expert lecturer validations obtained a mean of 3 with the category of valid. The validation results with valid categories describe that the developed lesson plan met the standard of excellent lesson plan components.

Worksheet

A worksheet refers to a collection of sheets consisting of tasks as directions for the learners to understand materials and to reach the learning objectives. The directions for filling out the worksheet are useful to guide the learners in carrying out experiments by reading the guidelines. This procedure allows learners to be

independent and not rely on the teachers directly to guide the experiment. The validity test of the worksheet consists of some assessment aspects, such as the experimental activity, the language aspect, the material, and the relevance of the STEM approach. The results of the validity calculation toward the worksheet with the following formula, Table 3.

Table 3. The Results of the Worksheet Validation

The Assessment Aspect	Results	Category
Experimentation	4	Valid
Language	4	Valid
Material	3.5	Valid
The relevance of the STEM approach	3.75	Valid

The aspect of experimentation consists of five sub-aspects: the experimentation based on the systematic and clear worksheet, the easily applied experimentation, the worksheet activity to enrich new learning experiences, the worksheet activity to facilitate learning objective achievement, and the worksheet activity to encourage learners. The results of the expert lecturer validations obtained a mean of 4 with the category of valid. The language aspect consists of five sub-aspects: the easily applied and less ambiguous language, the model and clear sentence implementation, the clear figure implementation in the worksheet, the relevance of the applied font type, and the relevance of the applied font size. The results of the expert lecturer validations obtained a mean of 4 with the category of valid. The aspect of the material consists of two sub-aspects: the relevant material between the core competence and the basic competence; and the relevance of the applied terms. The results of the expert lecturer validations obtained a mean of 3.5 with the category of valid. The results of the worksheet validity are generally valid. The aspect of the relevance with the STEM approach consists of four sub-aspects: the experimentation based on observation, the technology implementation, the science and technology implementation in practical life, and the calculation skills. The results of the expert lecturer validations obtained a mean of 3.75 with the category of valid. The validation results achieved a valid category. This finding describes that the developed worksheet meets the standard of excellent worksheet components.

The Learning Outcome Test

The applied learning outcome test is useful to examine the effectiveness of the promoted learning with the developed learning instruments. The developed learning outcome test is useful to examine the learning effectiveness with multiple choice and essay types to determine the learners' cognitive skills. The validation result of the learning outcome test consists of the aspects of material, construction, and language. Table 4 shows the evaluation results of the learning outcome test.

Table 4. The Results of Learning Outcome Validation

The Assessment Aspect	Results	Category
Content or material	4	Valid
Construction	4	Valid
Language	4	Valid

The aspect of the material consists of two sub-aspects: the relevance of the achieved basic competence, the relevance between the question and the measured indicator, the logical and homogeneous answer option, and the accurate answer selection. The results of the expert lecturer validations obtained a mean of 4 with the category of valid. The construction aspect consists of four sub-aspects: the formulated question core, the non-key answer question, the relatively similar formulation length, and the non-correlated question option with the previous question. The results of the expert lecturer validations obtained a mean of 4 with the category of valid. The language aspect consists of three sub-aspects: using the Indonesian language based on the standard, non-ambiguous answer options, and clear and understandable sentences. The results of the expert lecturer validations obtained a mean of 4 with the category of valid. Table 4 shows the results of the learning outcome validation. All presented items are valid. The question items in the learning outcome test are in line with the learning objectives. The arranged items are based on the scoring guidelines and directions based on the cognitive levels of the questions. The developed test arrangement is based on the correct and standard Indonesian language. The arrangement of the test is based on the criteria of an excellent test, such as practicability and clear assessment [13]. Daryanto & Dwicahyono [14] also explain that the arranged test must apply clear sentences to avoid ambiguity. The validation results of the test receive the category of valid. The results describe that the developed test could provide valid data to measure the learning effectiveness correctly. Table 5 shows the question item rubrics.

Table 5. Rubrics and the Question Examples

No.	The Indicators of the Question Items	Question items	Discussion
1.	Calculating the final velocity of an object	1) From the peak of the Enies Loby building, Chopper drops a cannonball. If the height of the building is 500m, calculate the speed of the	Given h = 500 m g = 10 m/s^2 Solutions $V_t^2 = 2.g.h$ $V_t = \sqrt{2.g.h}$

			cannonball once it touches the ground.	$V_t = \sqrt{2.10.500}$ $V_t = \sqrt{10000}$ $V_t = 100\ m/s$ The speed of the cannonball thrown by Chopper once it touches the ground is 100 m/s.
		2)	Agus drops a durian from a 20-meter-high tower. Calculate the speed of the durian once it touches the ground! a. 20 m/s b. 10 m/s c. 25 m/s d. 40 m/s e. 80 m/s	Given h = 20 m g = 10 m/s^2 Solutions $V_t^2 = 2.g.h$ $V_t = \sqrt{2.g.h}$ $V_t = \sqrt{2.10.20}$ $V_t = \sqrt{400}$ $V_t = 20\ m/s$ Thus, the speed of the thrown durian by Agus is 20 m/s once it touches the ground.
2.	Calculating an object's speed within a certain time	3)	Nathi drops an orange from the branch into the ground with an elapsed time of 5 seconds. Calculate the dropped orange's speed at 2 seconds if the g = 9.8 m/s^2.	Given g = 9,8 m/s^2 t = 2 s Solutions $V_t = V_0 + g.t$ $V_t = 0 + 9{,}8.2$ $V_t = 19{,}6\ m/s$ Thus, the speed of the orang at the 2 seconds after slipping from the branch is 19.6 m/s.
		4)	A coconut falls from the tree into the ground within 5 seconds. Calculate the speed of the fallen orange at 4 seconds if the g = 10 m/s^2. a. 20 m/s b. 10 m/s c. 40 m/s d. 50 m/s e. 25 m/s	Given g = 10 m/s^2 t = 4 s Solutions $V_t = V_0 + g.t$ $V_t = 0 + 10.4$ $V_t = 40\ m/s$ Thus, the speed of the fallen coconut at 4 seconds is 40 m/s.
3.	Calculating the time of the fallen object into the	5)	While chasing the enemy, Zoro unintentionally	Given h = 80 m g = 10 m/s^2

	ground		dropped off his sword. If the sword has fallen from an 80-meter height, calculate the time of the sword to reach the ground!	Solutions $t^2 = \frac{2.h}{g}$ $t = \sqrt{\frac{2.h}{g}}$ $t = \sqrt{\frac{2.80}{10}}$ $t = \sqrt{16}$ t = 4 s Thus, the time for the fallen sword to reach the ground is 4 seconds.
		6)	A bomb falls from 180-meter height, calculate the time to reach the ground! a. 9 s b. 18 s c. 3 s d. 6 s e. 2 s	Given h = 180 m g = 10 m/s^2 Solutions $t^2 = \frac{2.h}{g}$ $t = \sqrt{\frac{2.h}{g}}$ $t = \sqrt{\frac{2.180}{10}}$ $t = \sqrt{36}$ t = 6 s Thus, the time for the bomb to reach the ground is 6 seconds.
4.	Calculating the object height within a certain time	7)	Trafalgar Law drops a block of ice from a 50-meter height. Calculate the position of the iceberg after three seconds!	Given $h_0 = 50\ m$ t = 3 s Solutions $h = h_0 - \frac{1}{2} g.t^2$ $h = 50 - \frac{1}{2} 10.3^2$ h = 50 – 5.9 h = 50 – 45 h = 5 m Thus the position of the fallen rock after three seconds is at 5 meter height

			from the ground.
		8) Albert unintentionally drops a box from 100-meter height. Calculate the position of the box after 4 seconds! a. 20 m b. 40 m c. 10 m d. 25 m e. 5 m	Given $h_0 = 100\ m$ t = 4 s Solutions $h = h_0 - \frac{1}{2} g.t^2$ $h = 100 - \frac{1}{2} 10.4^2$ h = 100 – 5.16 h = 100 – 80 h = 20 m Thus, the position of the box after 4 seconds is 20 meters above the ground.
5.	Calculating the time of a fallen object from a certain height	9) A basketball falls from h meter above the ground. The speed of the ball once it hits the ground is 30 ms^{-1}. The required time to reach the 1/2 h above the ground (g = 10 ms^{-2}) is	Given g = 10 m/s^2 V_0 = 0 m/s V_t = 30 m/s Solutions $vt^2 = 2\ g\ h$ $30^2 = 2\ 10\ h$ h = 900/20 h = 45 m h = ½ g t^2 45 = ½ 10 t^2 t^2 = 45/5 t = 3 s Thus, the required time to reach 1/2 h above the ground is 3 seconds.
		10) A cannon ball falls from h height above the ground. The speed of the ball once it hits the ground is 20 ms^{-1}. The required time to reach the 1/2 h above the ground (g = 10 ms^{-2}) is . . . . a. 2 s b. 10 s c. 5 s d. 20 s e. 4 s	Given g = 10 m/s^2 V_0 = 0 m/s V_t = 20 m/s Solutions $vt^2 = 2\ g\ h$ $20^2 = 2\ 10\ h$ h = 400/20 h = 20 m h = ½ g t^2 20 = ½ 10 t^2 t^2 = 20/5 t = 4 s Thus, the required time to

			reach 1/2 h above the ground is 4 seconds.
6.	Calculating the height of a falling object	11) An apple falls from a tree with h height. If the required time to reach the ground is 5 seconds, calculate the height of the apple tree! (g = 10 m/s2)	Given g = 10 m/s^2 V_0 = 0 m/s s = 5 detik Solutions h = ½ g t^2 h = ½ 10.5^2 h = 5.25 h = 125 meter Thus, the height of the apple tree is 125 meters.
		12) A *keris* falls from a tower with h height. If the required time to reach the ground is 6 seconds, calculate the height of the tower! (g = 10 m/s2) a. 180 m b. 60 m c. 30 m d. 120 m e. 40 m	Given g = 10 m/s^2 V_0 = 0 m/s s = 6 detik Solutions h = ½ g t^2 h = ½ 10.6^2 h = 5.36 h = 180 meter Thus, the height of the tower is 180 meters.

D. Conclusion

Based on the assessment of the VBL-based learning instrument, the Tracker, with the PBL model, the validation result of the lesson plan is 3.65, the validation result of the worksheet with 381, and the learning outcome test validation with a score of 4. The whole validation results indicate a valid category. Based on the learning instrument validation result, the developed product, the physics learning instrument about the free-falling motion could be applied in the next development stage.

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Development of a Multimedia Learning Module (MLM) Based on Local Wisdom of the Banga Welu Game to Increase Student Motivation in Physics Learning

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ABSTRACT

This research aims to: (1) produce a multimedia learning module (MLM) based on the local wisdom of the Banga Welu game that is suitable and valid for use in learning, and (2) determine the effectiveness of a multimedia learning module (MLM) based on the local wisdom of the Banga Welu game in increasing motivation students in learning physics. This research is included in Research & Development (R&D) research according to the development design from 4D. The research design used in product trials is a pretest-posttest control group design. The subjects in this research consisted of 104 instrument and product testing students. Product validation was carried out using an ideal standard score (Sbi) and General Linear Model (GLM) with a significance level of 0.05 to test the product's effectiveness in increasing students' motivation in learning physics. The validation results of the validators show that the multimedia learning module (MLM) based on the local wisdom of the Banga Welu game is very suitable for use both in terms of the media aspect and the material aspect contained in it. The GLM with effect size result of students' physics learning motivation is 0.242 and is in the medium category. The results of this effect size test show that the multimedia learning module based on the local wisdom of the Banga Welu game effectively motivates students to learn physics.

INTISARI

Penelitian ini bertujuan untuk: (1) menghasilkan modul multimedia pembelajaran (MLM) berbasis kearifan lokal permainan Banga Welu yang layak dan valid digunakan dalam pembelajaran, dan (2) mengetahui keefektifan modul multimedia pembelajaran (MLM) berdasarkan kearifan lokal permainan Banga Welu dalam meningkatkan motivasi siswa dalam belajar fisika. Penelitian ini termasuk dalam penelitian Research & Development (R&D) sesuai desain pengembangan dari 4D. Desain penelitian yang digunakan dalam uji coba produk adalah pretest-posttest control group design. Subyek dalam penelitian ini berjumlah 104 siswa pada uji instrumen dan uji produk. Validasi produk dilakukan dengan menggunakan standar skor ideal (Sbi) dan General Linear Model (GLM) dengan taraf signifikansi 0,05

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untuk menguji keefektifan produk dalam meningkatkan motivasi siswa dalam belajar fisika. Hasil validasi validator menunjukkan bahwa modul multimedia pembelajaran (MLM) berbasis kearifan lokal permainan Banga Welu sangat layak digunakan baik dari aspek media maupun aspek materi yang terkandung di dalamnya. GLM dengan hasil effect size terhadap motivasi belajar fisika siswa sebesar 0,242 dan berada pada kategori sedang. Hasil uji effect size ini menunjukkan bahwa modul multimedia pembelajaran berbasis kearifan lokal permainan Banga Welu efektif dalam memotivasi siswa belajar fisika.

A. Introduction

Learning motivation is an important factor in learning activities. Learning motivation has an important influence on children's learning. Without learning motivation, learning is in vain. Motivation is also needed in the learning process because it is a parameter in determining the success of a learning process [1]. Teachers will easily convey lesson material if students' learning motivation is high [2]. This happens because learning motivation aims to move and encourage students to take part in teaching and learning activities [3]. Learning motivation plays an important role in creating the effectiveness and meaningfulness of learning [4][5].

The results of the preliminary study show that students' learning motivation is relatively low, especially in physics learning. This is proven by the fact that students are still found playing truant during learning activities. They also often come in and out of the classroom during teaching and learning activities without clear reasons. The cause of students' lack of motivation to learn is due to problems being experienced by students. Apart from that, there are too many calculations applied in physics learning and the presentation of the material is less interesting. Physics learning is rarely integrated with situations or activities that students often carry out in their daily lives [6]. The teacher-centered learning process is also another reason that student motivation is reduced. This kind of learning process reduces students' self-confidence in solving problems, thereby hampering the development of students' thinking abilities and reducing students' learning motivation [7].

The world of education today continues to innovate in learning. The learning process provided by educators in the classroom must be integrated with technology. One example of technology that can be used in the learning process is multimedia. Multimedia is a computer system consisting of hardware and software that makes it easy to combine various components. Multimedia is a combination of several media such as text, images, video, and animation which are used to help convey information and can be controlled by users whether used online or offline [8]. The use of multimedia is an effective and appropriate alternative for improving and enhancing the modern learning climate both in the classroom and outside the classroom [9]. The use of interactive multimedia makes learning more interesting and more interactive. The use of multimedia in learning will increase efficiency, and motivation, and facilitate active learning and experimental learning. The use of multimedia can facilitate all learning styles such as audio, visual, and kinesthetic [10].

One type of interactive multimedia that can be used in the learning process is the multimedia learning module (MLM). A multimedia learning module (MLM) is a unity or combination of video, audio, text, narrative, and animation packaged in several forms [8]. MLM is an introductory medium that aims to motivate students to actively participate in learning activities.

Physics learning places more emphasis on contextual aspects. Many phenomena in physics are often found or experienced in everyday life. Good learning suggests linking learning concepts with everyday life phenomena so that the knowledge transfer process becomes more meaningful [11]. Meaningful learning can be realized by integrating local wisdom in its implementation [12]. A type of local wisdom that can be integrated into the learning process is the Banga Welu game. The Banga Welu game is a type of traditional game originating from Manggarai, East Nusa Tenggara region [13]. The ingredients used in this game are candlenuts. The Banga Welu game can explain a lot of physics, one of which is the concept of momentum, impulse, and collision. The application of local wisdom in learning activities can make learning conditions more enjoyable. This allows students to feel their experiences in everyday life closer to learning [14]. Learning based on local wisdom makes students more relaxed in learning and can foster students' intrinsic motivation.

It is important to develop multimedia learning modules (MLM) based on local wisdom. The Banga Welu game in physics learning is important. Learning using multimedia learning modules (MLM) based on the local wisdom of the Banga Welu game can enable students to understand the concepts of momentum and impulse contextually and directly. The advantages and disadvantages of developing multimedia learning modules (MLM) based on the local wisdom of the Banga Welu game are expected to help increase student learning motivation.

B. Method

This type of research is development research with a 4D design (Figure 1). This research was carried out at SMAK St. Francis Xavier Ruteng, NTT. The research subjects were 36 students. Analysis of product validity data uses ideal standard deviation (Sbi) and analysis of increased learning motivation uses the N-Gain test. Product validation uses 2 experts and media application trial design uses pretest-posttest control group design. The technique for collecting learning motivation data uses non-test instruments in the form of learning motivation questionnaires.

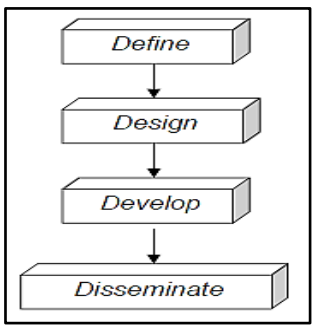

Figure 1. 4D Design

C. Result and Discussion

The product developed in this research is a multimedia learning module (MLM) based on the Banga Welu game. A multimedia learning module is a media used in the learning process with the Android system. Study materials, videos, animations, and example questions are found in this MLM. The materials, videos, and animations in this MLM are adapted to the local wisdom of the Banga Welu game. This media was developed using Adobe Animate software. The content in this media includes instructions for use, material on momentum and impulse, a video of the Banga Welu game, animation of the concept of momentum and impulse in the game of Banga Welu, example questions, and practice questions (Figure 2).

Figure 2. MLM display

This product assessment is carried out to determine the validity or feasibility of the MLM being developed. This product assessment was carried out by several assessors or validators consisting of media experts and material experts. The Banga Welu game-based MLM assessment includes 3 aspects, namely material, learning design, and language. The results of product assessments based on material aspects are analyzed using standard deviation assessment categories. The results of the feasibility assessment are shown in the following table.

Table 1. MLM Assessment Results by Material Experts

Aspect	Score	Category
Material	18.6	Very Feasible
Learning Design	22.6	Very Feasible
Language	3.8	Very Feasible
Overall	45	Very Feasible

Table 1 shows the results of the multimedia learning module (MLM) assessment analysis based on the Banga Welu game. The assessment results obtained are quantitative data with a score of 1 to 4. This data is then converted and analyzed using the standard deviation assessment category. The overall assessment of the Banga Welu game-based MLM product received a score of 45. Based on the results of the analysis and conversion to the standard deviation assessment category, it shows that this MLM is in a very suitable category for use. The assessment given by the validator is accompanied by suggestions for improvement, namely that the researcher needs to describe the material with a more straightforward definition the connection between local wisdom and the subject matter needs to be sharpened and the researcher must pay more attention to the use of more effective sentences. Meanwhile, the assessment of MLM based on the Banga Welu game based on media experts includes 2 aspects, namely the appearance aspect and the software engineering aspect. The assessment results are shown in the following table.

Table 2. MLM Assessment Results by Media Experts

Aspect	Score	Category
Display	22.4	Very Feasible
Software	7.2	Very Feasible
Overall	29.6	Very Feasible

Table 2 shows that the Banga Welu game-based MLM product in terms of media overall for all aspects received a score of 29.6. Based on the results of the analysis and conversion to the standard deviation assessment category, it shows that this MLM is in a very suitable category for use. The assessment given by the validator is accompanied by suggestions for improvement, namely the need to consider the consistency of the type and size of the letters, and the need to pay attention to the color of the media background.

Next is the trial stage which aims to see whether there is a difference in learning using the multimedia learning module based on the Banga Welu game on the learning implemented by teachers at school, especially regarding student learning motivation. Learning with different treatments for each class. Learning in the experimental class uses a multimedia learning module based on the Banga Welu game and learning in the control class uses no learning media.

To determine the increase in students' motivation to learn physics, two learning motivation questionnaires were given. The distribution of the initial questionnaire (pretest) was carried out to determine students' motivation to learn physics before participating in learning with the Banga Welu game-based MLM. Meanwhile, the administration or distribution of the second questionnaire (posttest) was carried out to find out students' motivation to learn physics after taking part in learning using

the Banga Welu game-based MLM. Knowing the initial and final scores of motivation to learn physics, it can be seen increase in students' motivation to learn physics after carrying out/participating in learning activities using the help of MLM based on the Banga Welu game. The results of students' physics learning motivation, both pretest and posttest, can be seen in the following table.

Table 3. Results of the Student Physics Learning Motivation

Class	Number of Students	Average Score of Learning Motivation	
		Pretest	Posttest
Experiment	36	74.4	93.2
Control	36	73.4	77.5

Table 3 shows the results of the student physics learning motivation questionnaire. Based on table 3 above, shows that the average student physics learning motivation for all classes in the pretest does not have too big a difference. This shows that students' initial motivation does not have much difference in participating in physics learning. After being given treatment in this case, the learning process increased learning motivation for all classes. The learning intended is learning with the help of MLM based on the Banga Welu game for experimental class 2. Learning using the help of PowerPoint media for experimental class 1 and learning without using the help of learning media in the control class.

Posttest results show that the average physics learning motivation of students in the experimental class is higher than the average physics learning motivation in the control class. This shows that the use of MLM assisted by the Banga Welu game in the learning process can increase students' motivation to learn physics. The N-Gain test was used to determine the increase in students' motivation to learn physics in the two sample classes as shown in the following table.

Table 4. Results of the N-Gain Test for Learning Motivation

Class	Average N-Gain	Category
Experiment	0.73	High
Control	0.15	Low

Based on table 4 above, shows that the N-Gain results of students' physics learning motivation in the experimental class are in the high category. Meanwhile, in the control class, the N-Gain results were in the low category. This shows that learning using the help of a multimedia learning module based on the Banga Welu game can increase students' motivation to learn physics. To see the N-Gain for each indicator of learning motivation, it is shown in Table 5.

Table 5. N-Gain for each Indicator of Students' Physics Learning Motivation

Class	N-Gain each indicator			
	Interest	**Attention**	**Participation**	**Doing Task**
Experiment	0.87	0.80	0.78	0.47
Control	0.32	0.06	0.15	0.08

The N-Gain results for each indicator show that the experimental class experienced better improvement than the control class with an average increase in the medium category. The indicator of doing assignments is one of the indicators with the lowest increase because some students still do not understand in detail the material being taught so that when doing assignments these students tend to be confused and unable to do it. This requires more intensive use of MLM so that students understand the material better and can do their assignments better.

The product developed in this research is multimedia learning modules (MLM) based on the Banga Welu game. This MLM is used in the learning process to increase students' motivation to learn physics. The study of the final product in the research focused on discussing the feasibility of MLM based on the Banga Welu game and the effectiveness of the Banga Welu game MLM in increasing student learning motivation. The multimedia learning module (MLM) based on the Banga Welu game that has been developed is a teaching material in the form of a multimedia module which is packaged in the form of an Android smartphone application by integrating the local wisdom of the Banga Welu game as a means of teaching physics concepts. The MLM based on the local wisdom of the Banga Welu game that was developed consists of a cover, login page, instructions for use, main menu, concept map, competencies, material content, examples, and practice questions. MLM content includes example questions, videos of the Banga Welu game, animations about the concept of momentum and impulse in the Banga Welu game, material concepts, and audio.

The feasibility of this Banga Welu game-based MLM was assessed based on an assessment of media, material, and trial aspects [15], [16]. Feasibility for media aspects and material aspects was assessed or validated by 2 experts (1 media expert and 1 material expert). The validation results show that MLM based on the Banga Welu game, in terms of material and media, is very suitable for testing. The revised MLM was then tested. Regarding learning motivation, the trial results show that the multimedia learning module based on the Banga Welu game is effective in increasing students' physics learning motivation. The multimedia learning module has a good impact on increasing the ability and motivation to learn physics. Multimedia learning modules are one solution for interactive physics learning modules that can be developed to fulfill technology-based physics learning [17]. The use of Multimedia learning modules is an effective and appropriate alternative to

improve and enhance the modern learning climate both in the classroom and outside the classroom [9]. The use of Multimedia learning modules can also improve the quality of student learning and can improve students' thinking abilities [18]. The use of Multimedia learning modules has a role in arousing curiosity in students. This makes students motivated to participate in the learning process [9]. MLM is an introductory medium that aims to motivate students to actively participate in learning activities. This MLM is packaged in several forms to reduce the ineffectiveness of using textbooks [19].

D. Conclusion

Based on the development results, analysis of research data, and discussion, it can be concluded that the results of the feasibility test show that the multimedia learning module of the Banga Welu game is suitable for use in the learning process. A multimedia learning module based on the Banga Welu game is effective in increasing students' motivation to learn physics. Apart from that, this product also helps teachers improve the quality of the learning process. This is because this product is integrated with technology. The multimedia learning module (MLM) product based on the Banga Welu game was declared feasible and effective for application in physics learning activities. The next stage of dissemination is to disseminate the product so that it can be innovated and developed in the field of education. The process of disseminating MLM products based on the Banga Welu game is carried out through Subject Teacher Deliberation (MGMP) forums, publications in journals, or educational seminars. Further development of MLM was carried out by developing similar products but based on local wisdom and different physical materials.

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The Development of an Integrated Physics Module with Augmented-Assisted-Qur'an for Measurement Material

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ABSTRACT
The main problems of current research are the limited measuring tools, handout-based teaching materials and 2D illustrated textbooks that are less varied, and the lack of integration of Al-Qur'an material with technology-based applications. In the educational field, one of the technological advancements is Augmented Reality (AR) which provides a shifting experience from 2D images to 3D. Therefore, technological integration is important to realize a physics module about measurement material and the Al-Qur'an to make students interested in learning by associating the teaching material and the everyday life context. This R&D applied the 4D model (Define, Design, Development, Dissemination). However, this research is limited to the practical development stage. The researchers used validation sheets from 3 aspects: material and media validation by 3 validators, and interpretation validation by 2 validators. The researchers distributed the practicality sheets to 2 teachers and 28 students The results of data analysis of material validation, media validation and expert interpretation obtained percentages consecutive percentages of 94.5%, 83.3%, and 91.6% with the category of very valid. Meanwhile, the practicality of the module based on the educators and students was 98.6% and 86.4% with the category of very practical.

INTISARI
Permasalahan utama penelitian saat ini adalah terbatasnya alat ukur, bahan ajar berbasis handout dan buku ajar bergambar 2D yang kurang variatif, dan belum terintegrasinya materi Al-Qur'an dengan penerapan berbasis teknologi. Dalam bidang pendidikan, salah satu kemajuan teknologi adalah Augmented Reality (AR) yang memberikan pengalaman peralihan dari gambar 2D ke 3D. Oleh karena itu, integrasi teknologi penting untuk mewujudkan modul fisika tentang materi pengukuran dan Al-Qur'an agar siswa tertarik belajar dengan mengaitkan bahan ajar dan konteks kehidupan sehari-hari. Penelitian dan pengembangan ini menerapkan model 4D (*Define, Design, Development, Dissemination*). Namun, penelitian ini dibatasi pada tahap pengembangan kepraktisan. Peneliti menggunakan lembar validasi dari 3 aspek yaitu validasi materi dan media oleh 3 validator, dan validasi tafsir oleh 2 validator. Peneliti membagikan lembar praktikalitas kepada 2 guru dan 28 siswa. Hasil analisis data validasi materi, validasi media, dan tafsir ahli memperoleh persentase berturut-turut sebesar 94,5%, 83,3%, dan 91,6% dengan kategori sangat valid. Sedangkan kepraktisan

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modul menurut pendidik dan siswa sebesar 98,6% dan 86,4% dengan kategori sangat praktis.

A. Introduction

The underlying background of this research includes a lack of student interest in learning physics lessons and the negative perceptions of the students about physics lessons as full-formula and conceptual memorization lessons. The absence of an accurate measuring instrument becomes the reason for educators do not reveal the instrument during learning. Most educators find this procedure will interrupt the students' attention and hinder the classroom learning time allotment. On the other hand, students unfamiliar with the studied measuring instruments may not understand the procedure to calculate with the measuring instruments.

Another research focus as the factor is – less material or learning source variations. Many teachers rely on library textbooks or summaries of material made directly by teachers. This book and summary of the material certainly do not maximize learning outcomes and require students to learn. These teaching materials also have some weaknesses for example the library books are only accessible during class time before being returned to the library once the class is up. This book package also still has a 2D image display which may fade in the future. The existing textbooks usually contain a collection of material that students will study for 1 year. Therefore, most library books are thick and heavy for the students. In addition, textbooks only focus on explaining the material rather than encouraging the students to understand. Likewise, with the summary of the material created by the teacher no matter how concise it is, only educators will understand the conclusion of the material. Thus, the absence of educator assistance makes students unable to understand the summary of the material. This material summary or book package is certainly not integrated with the Al-Qur'an or technology-based.

Many religion-based schools [1] emphasize the obligation to integrate the Al-Qur'an with learning for excellent value realizations of value, intelligence, nationalism, and independence. Therefore, these schools must instill religious values into learning materials [2] which has many positive effects. The absence of technology-based books and summaries of existing material makes the students not interested in physics. One of the applicable technologies to manage this situation is Augmented Reality (AR) with the capability to shift the 2D images into 3D [3], visualize the measuring instruments to students, and make the students interested. AR can also stimulate students' mindsets to think critically about problems in everyday life [4]. Learning modules are teaching materials with systematic and interesting arrangements, including materials, methods, and evaluations to be used independently by students [5]. A learning module is the smallest learning program unit that students can study independently [6]. In conclusion, a learning module is a form of independent teaching material for students, containing the studied material and the applicable methods in learning and evaluation. Thus, an integration of learning modules between Al-Qur'an and technology is possible.

Most educators explain the material in a lecture while the students pay attention and take notes without having time to understand the explanation. Therefore, students need an appropriate approach to improve student learning outcomes. One of the applicable approaches is a contextual approach with a focus on the student's activeness in finding related knowledge about the studied material. The contextual approach also begins with real examples from everyday life matter [7]. Another definition states that the contextual learning approach associates the discussed material and the real conditions for the students to earn and directly relate the newly acquired knowledge for further real-life implementation [8]. By implementing this approach, the learning experience will be meaningful and students could retain the information due to the discovery process of the students to construct their knowledge [9]. Based on the previous explanation, a learning module with a contextual approach assisted by Augmented Reality in measurement material could be an excellent solution for schools.

Many previous studies applied this type of integration. The first study developed an integrated module between Al-Qur'an and a CTL model of optical material [10]. The developed module integration, based on all aspects, was valid and practical. Another study found that a similar module development could overcome the learning difficulties about the material of fluid with AR-based Al-Qur'an [11]. The developed module was highly valid and practical because the students were also very interested in using the module during the learning process. A similar product was also developed in the form of an AR-based learning module that integrated the Al-Qur'an. The developed module could improve the student learning motivation. The developed module was also valid and practical to improve the student's scientific literacy [12][13].

From the literature review and the background, most developed modules with the mentioned integration have excellent results. However, those developed modules could not answer the current problems. Therefore, the researchers attempted to create an integrated module of the Al-Qur'an and technology-based with a relevant approach. The researchers attempted to maximize all aspects in overcoming the problems such as developing a module to overcome the difficult material to understand, following regional regulations by integrating them with the Al-Qur'an, providing appropriate approaches to improve learning outcomes, and applying the Augmented Reality technology to produce 2D images into 3D. These efforts are essential to a physics module for tenth graders about measurement material with the integration between Al-Qur'an and contextual approach by AR.

B. Method

This R&D research applies the 4D model: defining, designing, developing, and designing stages [14]. However, the researchers only conducted three stages: the defining, designing, and developing stages to produce a valid and practical module.

The validity of the module is divided into three aspects starting from validation of material, media, and interpretation by experts, the expert lecturers in the given fields. This validation aims to obtain useful suggestions for module revision purposes. Then, the researchers converted the obtained data with the following formula into quantitative data with a range of 1-5 To determine the level of eligibility, assessment criteria based on Table 1 are used [17] and the data will be processed using the equation (1).

Table 1. Validation Category

%	Category
0-20	Invalid
21-40	Less Valid
41-60	Fairly Valid
61-80	Legitimate
81-100	Very Valid

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

These percentage results are then organized into several categories [15]. The researchers analyzed the educator and student responses about the practicability of the developed module with the following formula (2). The results of the data presentation are organized into several categories based on Table 2 [15].

Table 2. Validation Category

%	Category
0-20	Impractical
21-40	Less Practical
41-60	Quite Practical
61-80	Practical
81-100	Very Practical

$$P = \frac{\sum \text{score of each item}}{\text{maximum score}} \text{ x } 100\% \quad (2)$$

C. Result and Discussion

Result

The questionnaire results found half of the students encountered difficulty with the measurement material due to various influential factors. They never used

measuring instruments such as micrometers, calipers, and various scales for the measurement material. Therefore, they encountered difficulties while calculating the measurement results from the given tools. On the other hand, the implementation of printed books and handouts, containing basic material, was not understandable for the students. However, they received this teaching material frequently during the learning process. Figure 1 shows the results of the questionnaire distribution.

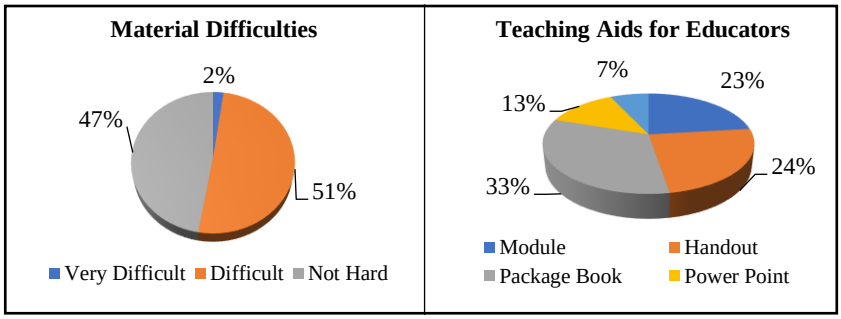

Figure 1. Student Questionnaire Results

Generally, the research participants preferred new things, for example, the technology implementation, to the conventional ones. Therefore, the development of this learning module as the teaching material could enrich students' learning resources and encourage students to understand the measurement material. This developed module could also manage the shortcomings or drawbacks found in handouts and textbooks. Figure 2 shows the student interests.

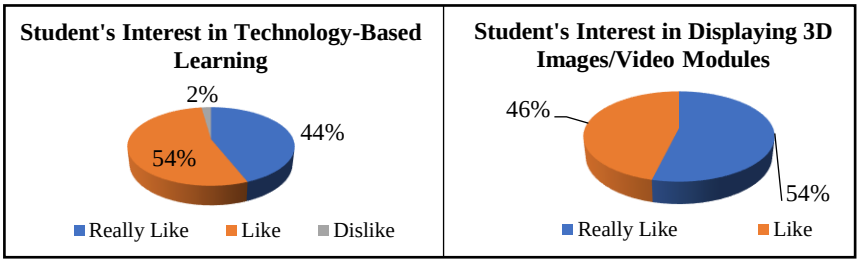

Figure 2.Student Questionnaire Results

The identification of the AR program for the designed module includes the efforts of determining the title, goal, objective, and material maintenance. Then, the process continued with creating the flow chart, from the opening until the closing parts. After that, the researchers revised the design based on the storyboard.

After completing the design, the researchers collected the material from various textbook sources. The researchers also collected various images and videos from several websites and YouTube channels. In the process of creating a QR code, the researchers utilized an application that could be downloaded from the Play Store or directly visited from the website called "Assemblr Edu". After collecting all materials,

the researchers combined all materials based on the specified design. Eventually, the researchers tested the module, especially the AR part. Figure 3 shows the results of AR testing.

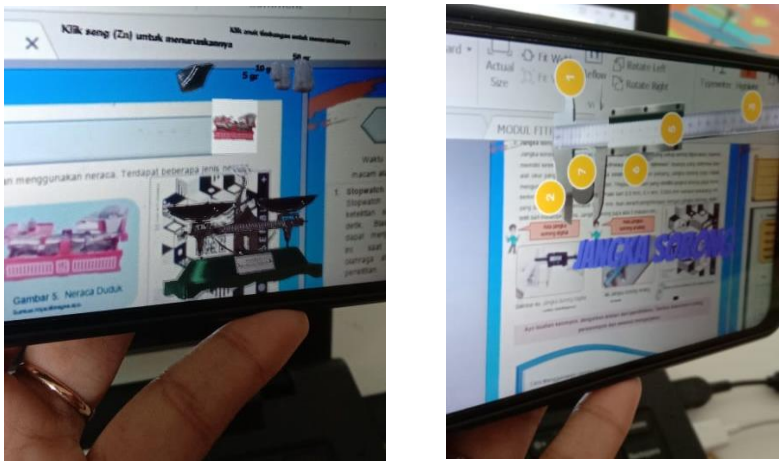

Figure 3. AR Trial

After designing the product, the researchers had the experts validate it. There were 3 material validators, 3 media validators, and 2 interpretation validators. Table 3 shows the validity results of the material. Table 4 shows the validity of the media while Table 5 with the interpretation.

Table 3. Material Validation Results

Aspect	Validator			Total	Max score	Score (%)	Category
	1	2	3				
Content Eligibility	49	53	52	154	168	91.7	Very valid
Feasibility of Presentation	19	20	18	57	60	95	Very valid
Language Eligibility	23	22	22	67	72	93.0	Very valid
Average						93.2	Very valid

Table 4. Media Validation Results

Aspect	Validator			Total	Max score	Score (%)	Category
	1	2	3				
Graphic Aspect	74	73	75	22	240	92.5	Very valid
Language Aspect	12	9	9	30	36	83.3	Very valid
Average						87.8	Very valid

Table 5. Interpretation Validation Results

Aspect	Validator		Total	Max score	Score (%)	Category
	1	2				
Content Eligibility	14	16	28	32	87.5	Very valid
Aspects of Feasibility of Presentation	7	7	14	16	87.5	Very valid
Aspects of Language Quality	22	20	42	48	87.5	Very valid
Average					87.5	Very valid

The validation process shows a very valid category. The results prove that the designed module is excellent [16], [17], [18]. The researchers also distributed practicality sheets to 2 physics teachers and 28 students from the tenth grade at MAN 2 Tanah Datar. The practicality results in the very practical category. This result is similar to the previous studies [19], [20]. Therefore, the module is very excellent to apply. Table 6 shows the practicability results based on the educators while Table 7 is based on the students.

Table 6. Results of Educator Practicality

Aspect	Validator		Total	Max score	Score (%)	Category
	1	2				
Ease of use	22	24	46	48	95.8	Very practical
Benefits obtained	24	24	48	48	100	Very practical
Effectiveness of learning time	12	12	24	24	100	Very practical
Average					98.6	Very practical

Table 7. Student Practicality Results

Aspect	Total	Maximum score	Score (%)	Category
Ease of use	688	784	87.7	Very practical
Benefits obtained	971	1120	86.7	Very practical
Effectiveness of learning time	285	336	84.8	Very practical
Average			86.4	Very practical

Discussion

After conducting interviews and observations with physics educators, the applied teaching materials during the learning process were still limited to library textbooks. This matter made the students could not take the books home. Other applied teaching materials were summaries of material made by the teachers without any integration with the Al-Qur'an. The available textbooks at schools and material summaries by educators only focused on discussing learning material and concepts.

From the results of interviews with teachers, the researchers found problems while applying teaching approaches such as teacher-centered learning. Based on the interview and the questionnaire results of the students, the researchers found that 33% of students argued the learning relied on textbooks; 24% of students argued the learning only used material summaries. This learning implementation made the students bored and not interested in learning due to the fixated atmosphere on the papers, written concepts, and written formulas.

Most students, 51%, experienced difficulties while learning the measurement material. This matter discouraged the students from reaching the learning goals moreover the implementation of less interesting teaching materials also contributed to this learning objective disencouragement. Based on the existing problems, the developed AR-assisted learning module is very suitable to apply. The developed learning module integrated the Al-Qur'an and contextual approach with the assistance of AR to provide a solution to existing problems.

At the next stage, the developed learning module integrated the Al-Qur'an and contextual approach with the assistance of AR has excellent design. The product collected various materials from various relevant sources about measurements in scientific work, backgrounds, videos, related verses of the Qur'an, and other supporting materials. The module design has several supporting applications such as Assemblr Edu, Canva, and Microsoft Word. Assembler Edu is useful for designing 3D designs with a QR-code output. This application can be downloaded on the Play Store. The module has a flowchart starting with the cover as the initial display of the module, the foreword, the table of contents, and the syntax of the contextual for the users to apply.

The developed module has some instructions for the teachers and students to do. The other instructions deal with AR implementation as the guide for the users in utilizing AR. After that, Learning Outcomes and Learning Objectives are also provided so that students can also know what objectives must be achieved after studying this material. The module also has a concept map and a presentation of the material. The module also provides the process of creating a storyboard with the contents of descriptions and images of the flowcharts. This learning module is designed starting from the cover, foreword, module specifications, instructions for using the module, instructions for using AR, learning outcomes and learning objectives, concept map, related Al-Qur'an verses to the material, placement of CTL syntax in the module, AR position location, material summary, competency test, self-assessment, final evaluation, and glossary.

After preparing the module, the researchers continued the process with the final stage: re-checking the errors and testing the module, especially the functionality of the AR part. After checking, the researchers printed the module and had the

supervisors share their feedback. After receiving suggestions, the researchers revised the module and disseminated the module for research purposes.

The validity of the integrated physics module with Al-Qur'an assisted AR, based on the validator, found the developed product was very valid and applicable. The obtained percentages are consecutively 83.3%-94.5%. In this process, the validators analyzed the module from the material, media, and interpretation aspects. Some previous studies also found the possibility of integrating modules with contextual approach and Qur'an with excellent product results [21] [22].

The practicability test found a practical category. Based on the teachers' responses, the obtained percentage of practicability was 98.6%, categorized as very practical. The result indicates the developed module is applicable, useful, effective, understandable, and interesting for the learners. A percentage of 86.4% of responses indicates the very practical category for learning. This result is similar to the previous studies that produced physics modules with the integration of contextual approach and AR implementation [20][23].

D. Conclusion

Based on the results of the research, the developed learning module has a material validity level of 94.5%, media 83.3%, and interpretation 91.6% with the category of very valid. The practicality based on the educator obtained a percentage of 98.6% while the students with a percentage of 86.4%, were categorized as very practical. Thus, the developed learning module integrated the Al-Qur'an and contextual approach with the assistance of AR applies to physics learning.

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The Effectiveness of SETS Learning Model toward the Misconception Decrease of Tenth Graders on Work and Energy Materials

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ABSTRACT
This study aims to determine the percentage of misconceptions in the work and energy sub-subject and to find out whether the SETS learning model is effective in reducing student misconceptions about work and energy. This research is quantitative research with the type of Pre-Experimental Design using the One Group Pretest-Posttest Design. The sampling technique used in this study was purposive sampling which is a technique for determining samples from members of the population with certain considerations by the desired criteria to be able to determine the number of samples to be studied by taking a sample of class X IPA 2, totaling 30 people. Based on the results of the pretest and posttest, the percentage reduction in misconceptions was 19.14% with an N-Gain of 44% which was included in the medium category. Research data were analyzed by normality test and hypothesis test. The results showed that the normality test using the Shapiro-Wilk test showed that the data were normally distributed with a pretest significance value of 0.842 and a posttest value of 0.520. The results of the research hypothesis using the t-test stated a significance value of 0.000, which means 0.000 <0.005 and H1 was accepted. The conclusion from this study is that the SETS learning model is effective in reducing the misconceptions of class X students on work and energy material.

INTISARI
Penelitian ini bertujuan untuk mengetahui persentase penurunan miskonsepsi pada sub materi usaha dan energi serta mengetahui apakah model pembelajaran SETS efektif untuk menurunkan miskonsepsi peserta didik pada materi usaha dan energi. Penelitian ini merupakan penelitian kuantitatif dengan jenis penelitian eksperimen semu *(Pre-Experimental Design)* menggunakan desain penelitian *One Group Pretest-Posttest Design*. Teknik pengambilan sampel yang digunakan dalam penelitian ini yaitu *purposive sampling* yang merupakan teknik penentuan sampel dari anggota populasi yang dilakukan dengan pertimbangan tertentu sesuai dengan kriteria yang diinginkan untuk dapat menentukan jumlah sampel yang akan diteliti dengan mengambil sampel kelas X IPA 2 yang berjumlah 30 orang. Berdasarkan hasil *pretest* dan *posttest* diperoleh hasil persentase penurunan miskonsepsi sebesar 19,14% dengan N-Gain 44% yang termasuk dalam kategori sedang. Data penelitian dianalisis dengan uji normalitas dan uji hipotesis. Hasil penelitian menunjukkan bahwa pada uji normalitas

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menggunakan uji Shapiro-Wilk menunjukkan data berdistribusi normal dengan signifikansi nilai *pretest* sebesar 0,842 dan nilai *posttest* sebesar 0,520. Hasil hipotesis penelitian dengan menggunakan uji-t menyatakan nilai signifikansi sebesar 0,000 yang berarti 0,000<0,005 dan H_1 diterima. Kesimpulan dari penelitian ini yaitu, model pembelajaran SETS efektif terhadap penurunan miskonsepsi peserta didik kelas X pada materi usaha dan energi.

A. Introduction

Everyone lives nearly with physics because everyone can experience the phenomena directly around their environment. All formal education receives the physics learning process as a method to understand the concepts, principles, and laws; and the relevances of the principles and concepts on the observed physics phenomena to direct the learners' conceptions [1]. When the learners interpret a concept personally, the interpretation could be defined as conception. Suparno [2] explains that conception refers to a capacity to understand a concept by interacting with the environment or formal education. Misconception occurs when the concepts of learners deviate from the scientific and agreed concepts and when the learners believe in their understanding of the constructed concept. A misconception or incorrect concept refers to an irrelevant concept with a scientific understanding of the incorrect conception of the learners [2].

Therefore, many researchers focus on the study of misconception with the scope of negative impacts on learning [3]. Difficulties in the complex misconception problems are sometimes unmanageable due to the learners' fossilized mindsets to change. This situation requires immediate management to prevent the fossilized misconception in later education or the future life of the learners [4]. By considering this situation, a method to manage misconceptions is important to design. Therefore, teachers must apply a complex learning model and provide learners opportunity to construct their languages by having relevant experience [4].

Misconception problems in various science fields especially physics are raised by researchers in which physics could discuss the phenomena in life [5]. The materials of work and energy in physics become a complex topic in the mechanics field [6]. The complexity is observable from the correlation among the concepts [7]. Learning physics is inseparable from facts, concepts, and theories of solving problems in daily life [8]. In this stage, the expectation of the learners with background knowledge of their life comes from the experience and the acquired information from the environment [9]. Tanjung & Hasibuan [10] also state that misconception is mostly observable on the topic of work because the learners cannot differ from the given force direction. The promoted work is the multiplication between force and displacement.

Misconception of learners is inseparable from the causes or the sources of notion incompatibility. Misconception may come from incorrect concepts or incorrectness in

combining the concepts [11]. Teachers, learners, textbooks, contexts, and teaching methods become the causes of misconceptions [2]. It happens because of prejudice, capability interest development period, thinking style, and individual relationships. Incorrectness committed by teachers occurs due to incapability, less subject mastery, inaccurate teaching methods, and poor behavior of the teachers. Misconception also occurs due to the experience and learning method without the available provision for the learners to reveal the arguments [12]. In this case, learners believe that teachers provide accurate teachings so that correcting misconceptions due to ineffective teaching methods provides challenges. Therefore, teachers must be aware of the materials of work and energy [13].

The researchers interviewed the teachers of tenth grade at Public Senior High School 1 Kalasan. The results revealed that the learners had misconceptions about the materials of work and energy. This matter happens because of the initial pre-conception of the learners from the learners' experience before learning the materials of work and energy. Misconception of learners deals with how the learners state that if an object does not receive any work, the object will not work at all. Besides that, when an individual promotes certain works but the object moves oppositely from the given work, this situation makes the individual not do any work. Lack of understanding during the learning process may include misconceptions about conservative-style topics. The interview results with the physics teachers also found that learners' misconceptions that were manageable by providing brief explanations. However, the researchers found no maximum efforts to manage misconception problems. Besides that, the assessment results of the learners, dealing with the conceptual understanding of work and energy, showed many learners had misconceptions. However, the greatest misconception percentage is 70%. In this case, the learners had a misconception of mechanical energy conservation law. The researchers also found that 57% of learners had misconceptions about the concept of work and 43% of learners had misconceptions about some questions about the concepts of work, kinetic energy, potential energy, and mechanical energy. The results showed the misconception of each concept of work and energy.

Silalahi [14], found that 64% of learners thought physics was a complicated and less attractive lesson to learn. They found the implementation of traditional learning models, such as lecturing and fewer teaching variations, made them have misconceptions. Therefore, many methods are applicable to manage misconceptions, such as applying the SETS learning model. The SETS learning model is abbreviated from Science, Environment, Technology, and Society proposed by Achmad Binadja. The paradigm of the SETS learning model focuses on the process instead of the product as suggested by constructivism. This criticism focuses on the cognition construction by finding, labeling, and organizing new materials [16]. SETS learning model aims to make the learners master the concept, improve their creativity, and

make them comprehensively understand problems [17]. Problem-solving skills and critical thinking of learners could be improved with the SETS learning model [18]. The increased critical thinking indirectly influences the conceptual understanding levels of the learners [19].

Previous studies found certain orders to conduct the SETS learning model such as empowering the concept with clarifications of the teachers to prevent misconceptions. The syntax of the SETS learning model includes initiation, conceptual development, conceptual application, conceptual empowerment, and evaluation. The syntax shows the focus of the learning model to empower the concept and prevent misconception. SETS learning model makes learners learn physics for more than science concepts including the science implementation into technology, environment, and society [19]. Some previous studies found that SETS could improve conceptual understanding and daily-life implementation [16], [19].

Misconception requires immediate management to prevent the impact of further misconceptions [20]. Poor and inactive conceptions of learners during the learning process may decrease understanding and lead to misconceptions [21]. Based on the explanations, and research about the "Effectiveness of SETS Learning toward the Decreased Misconception of Tenth Graders on the Materials of Work and Energy."

B. Method

This quantitative research consists of data collection and finding display. This pre-experimental design involved learners, grouped into experimental and control groups, based on the research objectives to manage misconceptions in a class due to the given treatment. This one-group pretest-posttest design only used pretest and posttest after the treatment [22].

O_1	X :	O_2
Pretest	*Treatment*	*Posttest*

Figure 1. Research Design

Remarks :
O_1 = Pretest before the treatment
O_2 = Posttest after the treatment
X = The treatment of the SETS learning model

The research site was at Public Senior High School 1 Kalasan and lasted from February to March in the even semester of the 2022/2023 academic year. The researchers chose the samples with purposive sampling. This sampling technique selects samples from a population based on pre-determined criteria [23] The samples

consisted of the learners from X Science 2 as the experimental group because the learners met the inclusion criteria, having the materials of work and energy for tenth grade. The researchers also used a diagnostic test, the four-tier test with multiple choices and closed answers as the research instrument. The researchers validated the instrument by involving two experts. They were the physics education lecturers and a physics teacher at senior high school. The researchers used the paired sample t-test to examine the hypotheses or examine the effectiveness of the SETS learning model in managing misconceptions. Before examining the hypotheses, the researchers examined the normality with the Shapiro-Wilk test.

C. Results and Discussion

Research Results

This research involved 30 learners from the X Science 2 class of Public Senior High School 1 Kalasan. Then, the researchers conducted pretest and posttest and put them into graphics.

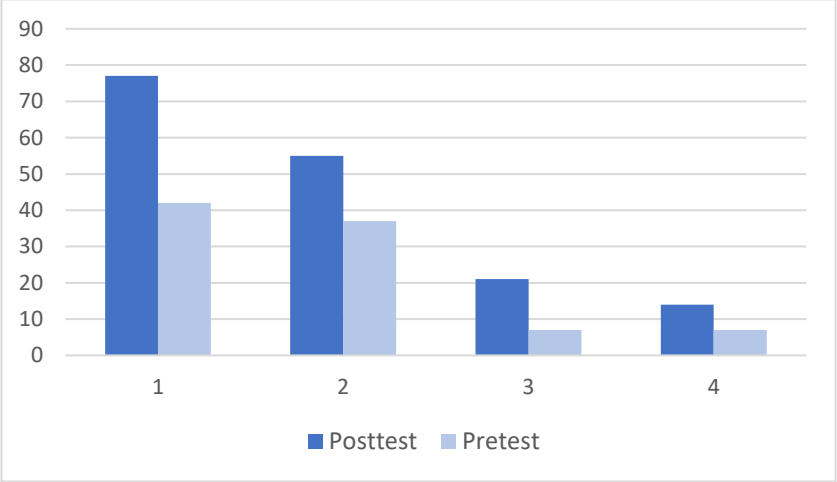


Figure 2. The Misconception Graphics of the Learners for Each Sub-Concept

The graphic shows the misconception occurrence by 30 learners on each sub-concept with 20 question items. The digit 1 states the sub-concept of work; the digit 2 states the sub-concept of potential energy, kinetic, and mechanic; the digit 3 states the mechanic energy conservation law concept; and digit 4 states the conservative and non-conservative forces. The pretest and posttest data found decreased misconception of the learners based on the patterns of the four-tier test answers with the analyses based on the sub-concept. Table 1 shows the results.

Table 1. The Mean Percentages of the Decreased Misconceptions

Sub-Concepts	Definition		
	no %	ni %	Δn (%)
Work	25.66	14.33	11.33
Potential, Kinetic, and Mechanic Energy	26.18	17.62	8.57
The Law of Mechanic Energy Conservation	70	23.33	46.67
The Conservative and Non-Conservative Forces	23.33	13.33	10
Mean Total	36.29	17.15	19.14

Remarks:

ni (%) : The percentage of misconceptions (posttest)

no (%) : The percentage of misconceptions (pretest)

Δn (%) : Misconception decrease

Table 1 shows the percentage mean is 36.29%. The percentage of posttest mean conception is 17.15% with the decreased misconception of 19.14%. The criteria of decreased misconceptions are observable with N-gain of pretest and posttest results.

Table 2. The mean percentage of decreased misconceptions with N-gain

Pretest	Posttest	Decreased Misconceptions	N-Gain	Criteria
36.29%	17.15%	19.14%	44%	Moderate

The data shows the decreased misconception based on the N-gin test with a percentage of 44%. The percentage shows the decreased misconception is at a moderate level. The described research data include the cognitive questions about the concept with the four-tier test. The questions consisted of 22 items. Figure 3 shows the pretest-posttest results.

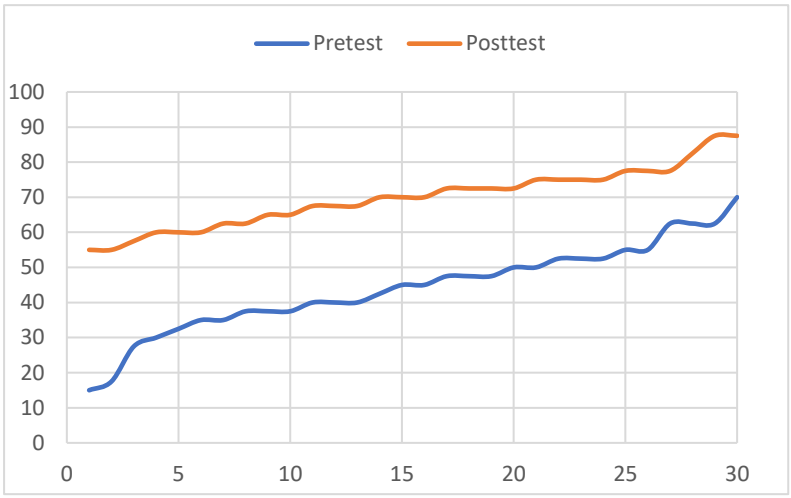


Figure 3. The Pretest and Posttest Score Results

The researchers used the Shapiro-Wilk test with SPSS to determine the distribution normality. The obtained data were useful to determine the normality. Table 3 shows the results.

Table 3. The Normality Test Data

Data	Shapiro-Wilk Test (Significance)
Pretest	0,842
Posttest	0,520

Table 3 shows the pretest with a significant score of 0.842 while posttest with 0.520. If the significant score of the Shapiro-Wilk normality test is higher than 0.05, the data has a normal distribution. The pretest-posttest scores show a significant level higher than 0.05, indicating the normal distribution data.

The hypothesis test is useful to examine the SETS learning model's effectiveness in decreasing the misconception of the learners. Once the test shows normal data distribution, the researchers will examine the hypothesis with a paired sample t-test.

Table 4. The Hypothesis Test

	Paired Differences				
	Mean	Std. Deviation	t	df	Sig. (2-Tailed)
Pretest-Posttest	- 25,67	12,33	-11,398	29	.000

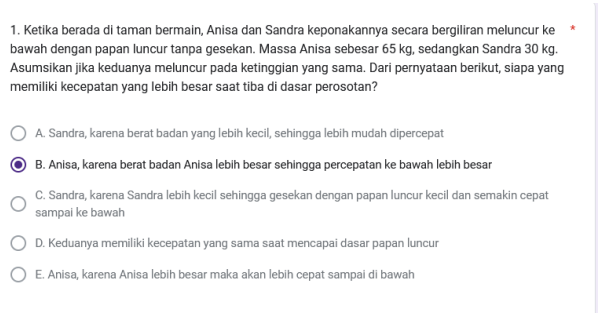
The proposed hypotheses are H_0: the SETS learning model is not effective in decreasing the tenth graders' misconceptions about the materials of work and energy; and H_1: the SETS learning model is effective in decreasing the tenth graders' misconceptions about the materials of work and energy. The researchers make the decisions of the hypotheses if the significance is higher than 0.05, accepting H_0 or else denying H_1. However, if the significance is lower than 0.05, accept H_1 and deny H_0. Table 4 shows the paired sample t-test. The significance is 0.000 lower than 0.005. Thus the result accepts H_1, indicating the effectiveness of the SETS learning model in decreasing tenth graders' misconceptions of the materials of work and energy.

Discussion

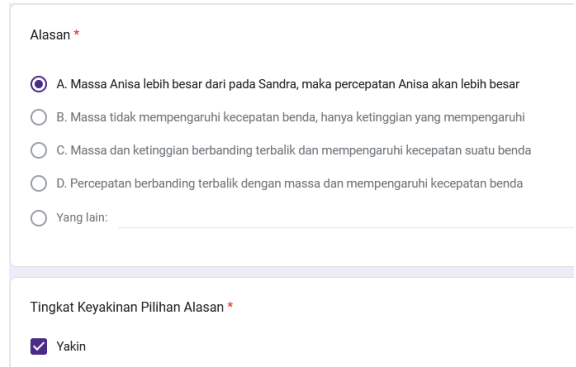
The pretest mean score of the diagnostic test with a four-tier test level is 44.15, indicating low conceptual cognition of the learners. Fitri, Sahala, & Oktavianty [24] also found some factors of low learning outcomes including misconception. The posttest mean increases to 69.83 after receiving the SETS learning model. In this research, the researchers found misconceptions occurred on all sub-materials of work and energy with different percentages.

The identification of misconceptions in this research is - some sub-concepts have misconceptions with varied criteria, from low to high criteria. The assessment results of the learners related to the cognitive questions about the material of works and energy also indicate misconception. However, the greatest misconception percentage is 70%. In this case, the learners had a misconception of mechanical energy conservation law. The researchers also found that 57% of learners had misconceptions about the concept of work and 43% of learners had misconceptions about some questions about the concepts of work, kinetic energy, potential energy, and mechanical energy. The following sections provide the analysis results of each question with high misconceptions based on the sub-concepts.

The misconception level on each sub-material of work and energy on the sub-concepts with high misconceptions such as the mechanic energy conservation law, based on the pretest, is 70%. After providing the treatment with the SETS learning model, the misconception decreased, proven by the posttest score of 23.33%. The score is categorized to be low. In this question, 90% of learners argued that high mass led to high acceleration. Suparno [2] explains that some misconceptions are - the mixed concepts between work and force. This case deals with mechanical energy conservation. The law says that energy cannot be created or eliminated but energy can be converted to other forms of energy by maintaining the same speed.



(a) the learners' answers



(b) the learners' arguments

Figure 4. Examples of the Questions

The sub-concept about work, question number 4, has incorrect answers of 56.67% on the pretest, categorized as moderate. The question discusses an inclined plane if it is associated with the elevation angle. Some learners thought small elevation angles led to high work. However, the applied equation of inclined planes is $m.g.s.\sin\theta$, indicating a high value of sin θ of an elevation angle, the experienced work is high. After receiving the SETS learning model, the increased misconception percentage is 26.67%.

The other high misconception is observable in the sub-concept of work with a percentage of 43.3%, on question number 3. Firstly, the work of an orbiting satellite around the Earth. Many learners thought that no gravitational force in outer space because the established resultant by the gravitation is 0 as a correct concept. The concept of work on the satellite is simple. If the motion is perpendicular to the force, then no work is established. After receiving the SETS learning, the misconception decreased to 20%.

Suparno [2] explains that learners may have various misconceptions about work as found in question number 14. The percentage of this misconception reaches a percentage of 43.3% about the work by force on rough surfaces. The learners thought

that the size of the work to move an object was influenced by the track. The size of the work by gravitation is equal for both tracks. It happens because the work by the gravitational force is dependent on the height position change instead of the track change to cover. After managing the misconceptions, the decreased misconception on the post-test is 26.6%. The percentage mean of the misconception on the sub-concept of work, before the treatment, was 26.18%. After providing the treatment, the decreased misconception percentage is 14.33%.

The other misconception before the treatment was about the sub-concept of potential, kinetic, and mechanical energy with a pretest score of 26.18%. After receiving SETS, the misconception decreased to 17.62%. The improvement total in the understanding of potential, kinetic, and mechanic energy is 8.57%. One of the complex questions for the learners is - the analysis of potential and kinetic energy on a shot bullet. Anggrayni & Ermawati [25] explain that learners may encounter difficulties although the question has the same concept to answer. The learners experienced misconception in analyzing the moment of the potential energy has no value or when the kinetic energy has no value. Maison, Lestari, & Widaningtyas [6] also explain a misconception that a moving object toward the ground has higher potential energy than kinetic energy. This misconception is a moderate misconception about potential, kinetic, and mechanical energy.

The misconception level of the sub-concept of conservative and non-conservative forces obtained a pretest percentage of 23.33%, categorized as low. However, after the treatment, the misconception decreased as shown in the post-test result with a percentage of 13.33%. The decreased misconception is by 10%. The most common misconception about the number-15 question is about an inclined plane. The proportion of the misconception is 26.6%. Learners could not accurately determine the converted energy by the non-conservative force. The learners also thought that frictional force was a conservative force. After receiving the treatment, the misconception decreased to 13.3%. Then, for question number 17 about the sizes of works and frictional fore and weight, the result shows a misconception percentage of 20% on the pretest and decreases to 13.3% on the posttest.

The total mean of the misconception percentage of the pretest is 36.295, categorized as moderate. Then, after providing the SETS learning model, the misconception decreased to 17.15% in the post-test, categorized as low. The decreased misconception on all sub-concepts of works and energy obtains a percentage of 19.14%. The decreased misconception is inseparable from the given treatment, the SETS learning model. The steps of the learning model significantly influenced the initiation and conceptual formation. In this initial stage, the researchers could determine the notions and arguments of the learners about society and environmental issues. Besides that, the concept enforcement is also important to manage misconception because in this step the concept is strengthened with important concepts to figure out.

D. Conclusion

Based on the results and discussions, the decreased misconception percentage of the tenth graders about the materials of work and energy is 19.14%, proven with a significant decrease from moderate to low category. SETS learning model (Science, Environment, Technology, and Society) is effective to use in the materials of work and energy to decrease misconceptions, as proven by the t-test result. The obtained significance is 0.000 lower than 0.005, accepting H_1 and denying H_0. SETS model is effective in decreasing the tenth graders' misconceptions about the materials of work and energy.

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The Development of a Problem-based Learning Physics Module to Facilitate the Critical Thinking Skills of SHS Learners for the Material of Work and Energy

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ABSTRAK

This research aims to develop a physics module based on problem-based learning to improve high school students' critical thinking skills in work and energy. The research also aims to evaluate the quality of the module and obtain student responses to its use. This research uses a 4D model, namely define, design, develop, and disseminate. The development stage only includes the development stage with extensive testing. There were 10 students randomly selected from classes XI Math and Science 2 and 4 for the limited trial phase, while 35 students from class XI Math and Science 3 for the extensive trial. The research instrument consists of a validation sheet, assessment sheet, and response questionnaire sheet. Module evaluation and student responses are presented in checklist form. The results of this research are: (1) producing a physics module based on a problem-based learning model to facilitate high school students critical thinking skills on the subject of work and energy, (2) the quality of the module that has been developed according to material experts, media experts and physics teachers is Very Good with the respective mean scores being 3.46, 3.58 and 3.74, and (3) the student's response to the module being developed was Agree with the mean score on the limited trial being 0.97 and on the extensive trial being 0.90. Thus, the development of a physics module based on problem-based learning to facilitate high school students' critical thinking skills on the subject of work and energy is suitable for use in physics learning.

INTISARI

Penelitian ini bertujuan mengembangkan modul fisika berbasis problem based learning untuk meningkatkan kemampuan berpikir kritis siswa SMA dalam usaha dan energi. Penelitian juga bertujuan mengevaluasi kualitas modul tersebut dan mendapatkan tanggapan siswa terhadap penggunaannya. Penelitian ini menggunakan model 4D, yaitu define, design, develop, dan disseminate. Tahap pengembangan hanya mencakup tahap develop dengan uji coba luas. Terdapat 10 peserta didik yang dipilih secara acak dari kelas XI MIPA 2 dan 4 untuk tahap uji coba terbatas, sedangkan 35 peserta didik dari kelas XI MIPA 3 untuk uji coba luas. Instrumen penelitian terdiri dari lembar validasi, lembar

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penilaian, dan lembar angket respon. Evaluasi modul dan tanggapan peserta didik disajikan dalam bentuk checklist. Hasil penelitian ini adalah: (1) menghasilkan modul fisika berbasis model problem based learning untuk memfasilitasi kemampuan berpikir kritis peserta didik SMA pada pokok bahasan usaha dan energi, (2) kualitas modul yang telah dikembangkan menurut ahli materi, ahli media dan guru fisika adalah Sangat Baik (SB) dengan rerata skor masing-masing adalah 3.46, 3.58 dan 3.74, dan (3) respon peserta didik terhadap modul yang dikembangkan adalah Setuju (S) dengan rerata skor pada uji coba terbatas 0.97 dan pada uji coba luas adalah 0.90. Dengan demikian, pengembangan modul fisika berbasis problem based learning untuk memfasilitasi kemampuan berpikir kritis peserta didik SMA pada pokok bahasan usaha dan energi layak digunakan untuk pembelajaran fisika.

A. Introduction

Energy and work are the physics materials for tenth grade as mandated by the revised 2003 curriculum. Energy and work are basic materials for the learners to master [1]. The materials are the parts of classic mechanic materials that review an object's motion from the starting until the stop points, and the causes of the object to move. Work and forces become the foundation for the subsequent materials, such as momentum, impulse, and harmonic motion. The understanding of work and energy is important because these materials are complex physical concepts. An excellent understanding of a material is important to solve problems properly [2]. This matter is observable in each correlated concept. In the interview results with the learners at Public SHS 3 Cilacap, the concepts of energy and work are complicated for the learners. The difficulties in learning the materials include the difficulties of different work and forces, understanding the work by the gravitational force, and determining the indications of the work of an object. The other difficulty is understanding the work of an object that makes the object move away [3].

The characteristics of work and energy materials are observable in daily life concepts. Many problems are useful as reference and guidance in learning so the learners can motivate their learning independently. The materials of work and energy do not only need an accurate learning model but also a teaching material to make the learners master the concepts and applications of the materials in daily life.

A preliminary observation at Public SHS 3 Cilacap found the teachers applied dictate and worksheets as the teaching materials. The applied strategy was teacher-centered learning. Many learners could not focus on the given materials because they were talking to each other, sleepy, and passive. They only noted the materials given by the teachers without any responses. The learners even did not share any argument and did not do the work. This matter made the learning interaction minimal and passive. Therefore, teachers should have been active in providing explanations while the learners should have been more active in constructing excellent understanding.

Before the facilitation to develop the critical thinking skills, the researchers found problems. Therefore, the learners required Problem-based Learning for physics learning. The module could facilitate the learners to be active in solving physics problems so the learners would not only learn physics concepts but also develop their critical thinking, communication, and problem-solving skills. The implementation of teaching material is interesting to improve the effectiveness of the PBL model.

Teaching materials refer to any applicable materials to help teachers or instructors in promoting the teaching-learning activity. The design of the teaching material could encourage learners to understand and find the concept so the learning would be more meaningful. One of the teaching Types of materials is a module. This module is a self-directed learning model with some steps of planned and designed learning systematically to facilitate learners in achieving learning objectives. The module is also applicable independently at any time and anywhere so that the module will not be hindered. The role of the teachers in using the module is not to dominate the learning but to focus the learners on learning [4]. The roles of the teachers as moderators facilitate learners to construct cognition actively. Besides that, the relevance of the addressed curriculum on the model is based on the objectives and the attempts to achieve the objectives, to make the learners correlate with learning, and with processing the results [5]. The efforts of teaching material and learning model could improve the critical thinking skills of the learners and arrange teaching materials in the form of an integrated model with the PBL model. The physics module based on PBL makes the problems the context and motor for the learners to learn [6]. The PBL-based module could motivate learners to learn, construct comprehensive knowledge, improve cognitive skills, solve problems, collaborate, communicate, and think critically [7].

Based on the explanation, the researchers developed the teaching material in the form of a printed module for the materials of work and energy. The researchers expect the developed module could meet the learners' necessities as an independent learning source. The implementation of the PBL model could facilitate the critical thinking skills of the learners.

B. Method

This research and development applies the 4D model: defining, designing, developing, and disseminating. The researchers developed the product until the developing stage specifically the massive trial run. The respondents during the trial run were 10 learners taken randomly by the physics teacher of XI Math and Science 2 and XI Math and Science 4. Then, during the trial run test, the research involved 35 learners of XI Math and Science 3. The applied instruments were validation, assessment, and learner questionnaire sheets. The assessment of the module quality applied the 4-scale Likert scale: 4 (extremely excellent), 3 (excellent), 2 (under average), and 1 (extremely under average). On the other hand, the questionnaire

response of the learners applied the 2-scale Guttman: agree and disagree. The researchers used a checklist to assess the module quality and response questionnaire.

C. Result and Discussion

The Defining Stage

This 4D research design consists of defining, designing, developing, and distributing. In this research, the researchers focused on the developmental stage with the product-trial run. The trial run lasted in two steps: the limited and massive trial run at Public SHS 3 Cilacap. The first step deals with defining the problem in the learning process to design the appropriate module. The learners encountered difficulties understanding the physics concept of work and energy and the solution [8]. The implementation of a physics module based on PBL could manage the difficulties and facilitate the learners to be active and improve their problem analysis [9]. After the analysis, the researchers could formulate the indicators of achieving the competencies based on the problems.

The Designing Step

In this step, the developed module is based on the analysis of the learners' necessities that had no independent learning media. This module consisted of problems related to contextual matters. The module format is based on the ideal module criteria by the National Education Department. The determination of the applied basic competence becomes a reference to arrange the indicators of cognitive and psychomotor competence achievements. The arranged module refers to the revised 2003 curriculum at Public SHS 3 Cilacap.

Module I consists of opening, content, and closing. The opening consists of module information and competence, the content part with material and learning activity, and the closing with a glossary, reading list, and author's information. The opening part of the module begins with the front cover, consisting of general descriptions of physics module content based on problem-based learning about the materials of work and energy to facilitate the learners' critical thinking skills. The front cover presents 4 figures: tug of war, carrier man, rafting man, and cyclist. Besides that, the writing of "Work and Energy" on the upper part and the writing of "Based on Problem-based Learning" on the lower part could provide descriptions for the learners that the developed module is - the module of work and energy based on PBL.

After the front cover, the module has a preface, table of contents, and module manual. The content of the module could facilitate the learners to find the material pages and so do the module manual. These features provide information and facilitate learners to use the module. Then, in the introduction part, the module has module

identity, core competence, basic competence, competence achievement indicator, and module description.

The core parts of the module begin with a conceptual map of work and energy to provide an understanding of the material. Then, the introduction part elicits questions to facilitate learners gaining meaningful understanding. The module also has an explanation of the learning activity with specific objectives for each activity. The module consisted of three learning activities, such as the materials of work, energy, and the law of energy and power conversion.

In every learning activity, some columns provide the PBL stages such as the study case, let's think, activity, train your skill, and question. The learners encounter problems in their daily lives to solve in groups. They also promote investigation, development, and presentation of their works. This module refers to the Watson-Glaser critical thinking skill indicators. The indicators suggest learners assume, evaluate arguments, and draw conclusions. This core competence also covers the material summary, formative test, and reflection. The summary facilitates the learners to understand the materials quickly while the formative test measures their understanding levels.

The closing part has the key answers of the formative test and the tasks of each learning activity to allow learners to work on the questions in the module and determine the correctness of the answers. On the following page, the module has a glossary to facilitate learners in finding the definitions of the terms from the previous explanations. The developed module arrangement has relevant references to the physics material discussion. Therefore, the researchers put the reading lists at the end of the module.

The Development Stage

The validation of the physics module based on PBL for the materials of work and energy is useful to determine the validity and relevance between the presentation and the module content. The researchers asked the assistance of material and media experts to validate by filling in the validation sheet. The validation sheet contains a validation table with some remarks such as valid without revision, valid with revision, and invalid. Besides that, the pages are useful for the experts to provide suggestions and recommendations for the developed module. Here are the revisions for the developed module based on the criticisms and suggestions of the material and media experts.

1. The Material Expert Validation
    a. Expert 1 criticized the consistency of the multiplication operator, the dot (.), for each equation and the importance of considering the measurement types whether they are scalar or vector.

b. Expert II suggested the researchers not to use the word 'mengetahui' or 'knowing.' The expert argued the word was not operational and could not be measured. The expert also criticized the remarks of the figures.

2. The Media Expert Validation
   a. The expert I suggested the figures, on the front cover, be adjusted with the module content. The other suggestion deals with font size and tidiness.
   b. The expert I suggests the researchers provide the indicators of competence achievements and learning objectives with some explanations on each point.
   c. The expert I suggested the syntaxes of PBL to be visible, briefly, and tidily put on the module.
   d. The expert I suggested the equation of power (P) was not correct.
   e. The expert suggested using the term reading list instead of bibliography.

These revisions were useful to arrange module II. Then, the researchers involved the experts in media and material and the physics teachers to assess the revised module. The assessment involved two experts of material and media; and two physics teachers. The assessment step has qualitative data with the categorization based on each indicator: extremely excellent (SB), excellent (E), under average (UA), and extremely under average (EUA). The researchers converted the qualitative data with the Likert scale and obtained the quantitative data to determine the quality of module II. Besides that, the assessment of the module provided some suggestions as further consideration, for revision II. Here are the parts of the revised physics module based on the suggestions and recommendations of the experts.

1. The Material Expert's Assessment

The two material experts assessed the physics module based on material validity, PBL implementation, and critical thinking skills. The material validity aspect has two indicators to assess. The first indicator was the material relevance with the learning objectives and core and basic competencies. The second indicator dealt with the conceptual map, the concept of work and energy, and question examples. The combination of the materials uses many references such as books, journal articles, and Internet sources. The obtained score of the aspect assessment was 3.50 with the category of extremely excellent (EE).

The expert also assessed the steps of PBL of the module. The module had 5 PBL steps, such as problem orientation for the learners, learner organization for the learners, individual or collaborative investigations, development and presentation of the work, and analysis and evaluation of the problem-solving process. The mean score of the aspect is 3.67 with the category of extremely excellent (EE). The problem presentation of the module was interesting and relevant to the development of science.

The final aspect was - critical thinking skills. The researchers assessed three indicators: recognizing the assumption, evaluating the argument, and drawing a conclusion. The mean score of the aspect is 3.2 with the category of excellent, E. The

column "Mari Berpikir!" facilitated the learners to analyze information objectively and accurately based on the learners' arguments. Thus, overall, the developed module was excellent in terms of material, PBL implementation, and critical thinking skills. Here are the module parts to follow up based on the material experts' suggestions.

a. For the assessor, I suggested the writing of the equation to be more consistent by using the symbol of dot (.) or not using it for both the materials and the question examples.
b. The assessor suggested providing relevant examples and illustrations with the field facts.
c. Assessor II suggested adding the indicators of energy-conversion law achievement as mandated by the Basic Competence.
d. This assessor suggested correcting the writing of any incorrectly typed words.

2. The Media Expert's Assessment

Two media experts assessed the developed module from three aspects: content validity, linguistic validity, and graphic validity. The obtained mean of the material validity was 3.67 with the category of extremely excellent (EE); the linguistic aspect with 3.50 and the category of extremely excellent (EE), and the graphic aspect with 3.58 and the category of extremely excellent (EE). After obtaining the scores on aspects, the researchers summed up and divided the scores with the numbers of the aspects. The obtained mean was based on the expert media assessment. The obtained mean of each aspect is 3.58. Based on the criteria of the product assessment, the mean score is categorized as extremely excellent (EE). Here are the revised module parts based on the suggestions and recommendations of the media experts.

a. The assessor II suggested the researchers always put full stops (.).
b. The assessor suggested the researchers use an italic format for each English word.
c. The assessor suggested enlarging and making all figures clear.
d. The assessor suggested changing the colors of the back cover since it was dark and pixelated.

3. The Assessment by Physics Teachers

The teachers assessed the content, presentation, problem-based learning implementation, and critical thinking skills. The material validity was based on the material relevance with the indicators and learning objectives such as the comprehensiveness of the material based on the learners' developments and the material relevances with the physics concepts. The mean of the aspect was 3.70 with the category of extremely excellent. The aspect of presentation deals with the presentation technique, material-figure relevance, font size, font combination, and punctuation. The mean of the aspect was 3.75 with the category of extremely excellent.

The aspect of the PBL model consisted of 5 PBL steps. The mean of the aspect was 3.70 with the category of extremely excellent. The critical thinking skill dealt with three indicators of critical thinking skills: recognizing the assumption, evaluating the argument, and drawing a conclusion. The mean of the aspect was 3.8 with the category of extremely excellent. Based on the analysis, the mean of all assessed aspects of the physics teachers was 3.74 with the category of extremely excellent. The result shows the developed module was valid to use as teaching material.

Here are the revised module parts based on the teachers' recommendations and suggestions.

a. The physics teacher I suggested explaining the concept of work from the basics and providing illustrations.
b. The teacher suggested adding more references from books such as Tipler, Giancoli, etc.
c. The teacher also suggested the researchers provide the term definitions, use understandable language, and use correct concepts.
d. The physics teacher II suggested the questions parts of the second learning activity be added with questions about potential energy, mechanic energy, and kinetic energy.
e. Physic teacher II suggested improving the incorrectly-typed sentences.

After revising the module, the following step was - promoting limited tests and massive trial runs to determine the learners' responses. The limited test involved 10 learners of XI Mathematic and Science class of Public SHS 3 Cilacap, selected by the physics teachers. The researchers collected the data face-to-face at the school. The researchers explained to the learners and asked them to fill in the response sheet. The sheet consisted of positive and negative statements to answer: disagree or agree. The learners answered based on their arguments. The obtained responses were 25 statements grouped into 4 aspects: the presentation, PBL model implementation, critical thinking skill, and material validity. After promoting the limited test, the researchers found the four aspects had a mean score higher than 0.50. The results showed the learners' responses were mostly agree. Besides sharing the responses, the learners also criticized and shared suggestions. The suggestions dealt with incorrect writings and unclear figures on the module's cover. Then, the researchers used the criticisms and suggestions to revise.

After promoting the limited test, the researchers did a massive trial run for the XI Math and Science 3 learners at the school. The test involved 35 learners. Then, the researchers explained the module parts from the introduction until the closing. The learners had 30 minutes to fill in the responses, consisting of 35 statements with 4 aspects: presentation, PBL implementation, critical thinking skill, and material validity. Based on the data, most learners agreed with the aspects on the response sheet. The mean scores of the presentation, PBL implementation, critical thinking,

and material validity were 0.90, 0.92, 0.89, and 0.89 with the categories of agree. The learners also shared their suggestions for the developed module. The mean score of the module was 0.90 with the category of agree. The developed module could be a learning reference to facilitate the learners' critical thinking skills. Critical thinking skills allow learners to learn systematic problems and manage the challenges in an organized manner; formulate innovative questions; and design original solutions.

Many previous research support this research. Fauziah [10] also found similar research results: the material aspect mean score of 356 with the category of extremely excellent; the presentation aspect mean score of 3.79 with the category of extremely excellent; and the graphic aspect with the mean of 4.00. The results are similar to current research, especially about the applied PBL syntaxes and the problem of the material, the daily life. Besides that, the researchers found the differences with the previous research such as the developed physics module. The previous module did not clearly explain the PBL syntaxes, lack of materials, and lack of illustrations or figures. On the other hand, the currently developed module shows the PBL syntaxes for each learning activity with detailed material explanations and clear illustrations or figures.

Sari [11] and Himawan [12] also found the implementation of the module could improve the learners' critical thinking skills. This matter happens because the module presents various components to encourage the learners to think critically about the concepts of work and energy [11]. Sari [13] and Himawan [14] also developed a physics module with the content of daily life.

The previous research also supported the implementation of a physics module based on PBL. The collaboration between the problem-based learning approach and the independent teaching materials could provide innovative education products. The developed module could guide the learners in solving the problems gradually. Jayanti [15] explained that the module based on PBL excellently influenced the analytical skills of learners. Therefore, based on the learners' responses on the limited test and massive trial run, the developed module based on PBL was valid to use in physics learning.

Generally, the developed module has some strong points such as the colorful figures. The problem in the module deals with the daily activities encountered by the learners; the presentation of formative tests for each learning activity to evaluate the learning, and the content of the module with the implementation of PBL to facilitate the learners in thinking critically and solve problems. These matters facilitate the learners to monitor their cognitive progress. On the other side, this module has some drawbacks such as a lack of question variation; limited daily life content for the formative test questions; the A4 size module; and a lack of flexibility.

D. Conclusion

The developed physics module based on PBL was for the materials of work and energy as the learning source. The quality of the developed module for the materials of work and energy could facilitate the learners' critical thinking skills. The experts of materials and media shared a mean score of 3.59, indicating an extremely excellent category. Thus, the developed module is applicable as a learning source. The learners' responses toward the developed module for the materials of work and energy were positive. They found the module could facilitate critical thinking skills. The learners agreed with the module and obtained a mean score of 0.97 in the limited test and 0.90 in the massive trial run.

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Development of Multi Representative Physics E-Module with the Materials of the Momentum and Impulse Grade X High School/Islamic High School Students

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ABSTRACT

The module is a teaching material that is packaged practically and systematically so that it can be accessed independently by both teachers and students. E-modules are adaptations of learning modules to the current digital era, so that in operation e-modules utilize technology, both computers and cellphones. This study aims to 1) produce multi-representation-based physics e-modules on momentum and impulse material that can be used in learning, 2) determine student responses related to multi-representation-based physics e-modules that have been produced, and 3) determine the quality of physics-based e-modules multi representation that will be used in classroom learning. This research belongs to R&D (Research and Development) research with the 4D Thiagarajan development model consisting of Defining, designing, Development, and Disseminating. This research is limited to the Development stage, to be precise, in extensive trials. The instruments used in this study included validation sheets, assessment sheets, and student response questionnaires. E-Modules are validated by material experts and media experts. The validation sheet in this study uses Aiken's V scale with three scales. In comparison, the e-module quality assessment was conducted by two material experts, two media experts, and two physics teachers. The e-module quality assessment sheet uses a Likert scale with four scales. The e-module trials in this study were divided into two stages: limited and extensive. Limited trials were conducted on ten students, while comprehensive trials were conducted on 36 students. Student response questionnaires used the Guttman scale with two scales: "agree" and "disagree" statements. The results of this study include: 1) multirepresentation-based physics e-modules on the subject of momentum and impulse have been produced to facilitate students' learning styles; 2) the quality of the e-module that has been developed based on material experts, media experts, and teachers has a successive average score of 3.29 in the very good category; 3.66 with very good category; and 3.74 with very good category; 3) The response of students to the e-module in limited trials and wide trials has a successive average score of 1.00 with the agreed category; and 0.95 with the agreed category.

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INTISARI

Modul merupakan suatu bahan ajar yang dikemas secara praktis dan sistematis sehingga dapat diakses secara mandiri baik oleh guru maupun peserta didik. E-modul merupakan adaptasi modul pembelajaran terhadap era digital saat ini, sehingga dalam pengoperasiannya e-modul memanfaatkan teknologi baik itu komputer maupun handphone. Penelitian ini bertujuan untuk 1) menghasilkan e-modul fisika berbasis multirepresentasi pada materi momentum dan impuls yang dapat digunakan dalam pembelajaran, 2) mengetahui respon peserta didik terkait e-modul fisika berbasis multirepresentasi yang telah dihasilkan dan 3) mengetahui kualitas e-modul fisika berbasis multirepresentasi yang akan digunakan pada pembelajaran di kelas. Penelitian ini tergolong ke penelitian R&D *(Research and Development)* dengan model pengembangan 4D Thiagarajan yang terdiri dari *Define, Design, Development dan Disseminate*. Penelitian ini dibatasi ada tahap *Development*, tepatnya pada uji coba luas. Instrumen yang digunakan pada penelitian ini antara lain lembar validasi, lembar penilaian dan angket respon peserta didik. E-Modul divalidasi oleh ahli materi dan ahli media. Lembar validasi dalam penelitian ini menggunakan skala *Aiken's V* dengan 3 skala. Sedangkan penilaian kualitas e-modul dilakukan oleh 2 ahli materi, 2 ahli media dan 2 guru fisika. Lembar penilaian kualitas e-modul menggunakan skala *likert* dengan 4 skala. Uji coba e-modul pada penelitian dibagi menjadi 2 tahap yaitu uji coba terbatas dan uji coba luas. Uji coba terbatas dilakukan terhadap 10 peserta didik, sedangkan uji coba luas dilakukan terhadap 36 peserta didik. Lembar angket respon peserta didik menggunakan skala *guttman* dengan 2 skala yaitu pernyataan "setuju" dan "tidak setuju". Hasil penelitian ini antara lain: 1) telah dihasilkan e-modul fisika berbasis multirepresentasi pada pokok bahasan momentum dan impuls untuk memfasilitasi gaya belajar peserta didik; 2) kualitas e-modul yang telah dikembangkan berdasarkan ahli materi, ahli media dan Guru memiliki rerata skor berturut-turut sebesar 3,29 dengan kategori sangat baik; 3,66 dengan kategori sangat baik; dan 3,74 dengan kategori sangat baik; 3) Respon peserta didik terhadap e-modul pada uji coba terbatas dan uji coba luas memiliki rerata skor berturut-turut sebesar 1,00 dengan kategori setuju; dan 0,95 dengan kategori setuju.

A. Introduction

The Regulation of the Republic of Indonesia, Number 20 the Year 2003 Article 1 Clause 1 about the National Education System [1], education presents a learning process to develop the potential and skills they need. Education guides students to become citizens who are aware of their rights and duties so that they can benefit the country. The success of an education depends on the factor of learning. Pane [2] explains an ideal learning process must have an interaction between components that include teachers, students, learning objectives, learning media, teaching materials, methods, and evaluations.

The learning process aims to produce students with better quality. But the reality says otherwise, the quality of education in Indonesia is currently poor. It is based on a survey by TIMSS [3] which aims to determine the level of understanding of students related to mathematics and science. Referring to this survey, the average student answered correctly on the knowing aspect at 32%, the applying aspect at 24%, and on the reasoning aspect at 20% [3]. Indonesia ranks 45th out of 48 countries that followed the survey.

The low level of understanding of science can be influenced by several factors, such as the teaching material or modules in learning. Asyhar cited by Permadi [4] explains that a module is a print-based teaching material that is accompanied by instructions and is independently accessible by both students and teachers. Kuswandaria cited by Sa'idah [5] explains that the weaknesses of the teaching materials used today are the strategies of organizing and delivering materials that are not well structured as well as their less attractive packaging. This lack of teaching material will undoubtedly hamper the student's understanding of the material of science, especially physics.

Physics is the genius of science that triggered the radical revolution of human civilization. Abdurrahman [6] explains that physics presents a more general method for solving complex problems. Based on this, physics has a bad image as a subject in school due to its difficulty in understanding the material in it and also the low interest of students in studying physics. Jiwanto [7] explains that one of the constraints encountered by students in studying physics is that they tend to find it difficult to solve problems. Physics deals with problems that require students to be able to think critically in solving them.

Kurniasari [8] explains that the problem-solving skills of the students can be enhanced by expanding the concept and justifying the concept against the physics material taught. A lack of understanding of the concept can hinder the student from solving the problem of a phenomenon presented. Referring to that, then the student's understanding of the concept of physics should be emphasized. Therefore, there is a

need for a collaborative method to improve the understanding of concepts, one of which is the multi-representation method.

Suminar cited by Rendiyansah [9], multirepresentation refers to a method of presenting similar concepts with different methods. Murtono [10] explains that multi-representation complements the cognitive process of the learners to obtain complete concepts. Mardatila [11] explains that poor conceptual understanding requires various representations to facilitate learners in understanding the concepts. Permadi [4] explains that the student's understanding of the concept of physics is not centered on a single representation but on many representations obtained through various sources and references.

Based on the results of the preliminary study of unstructured interviews obtained that students at 08 Yogyakarta Public High School have difficulty in understanding the physical concepts, especially on matter momentum and impulses, this is because students have not mastered the concepts of vectors optimally. The difficulties experienced by the students related to the understanding of concepts, Farida cited by Sa'idah [5] states that the students make incorrectness in solving abstract problems on momentum and impulse material, the learning media used by teachers in the teaching-learning process include tablets, power points and worksheet with limited concept presentation.

Then based on the observations obtained that learning in schools is still centered on the teacher and the minimum demonstration. Physics labs in schools are also rarely used for practicums, it's marked with laboratory tools that have been dusty and also descriptions from laboratory managers. In addition, the use of technology in Yogyakarta State High School 08 is quite massive, but the empowerment of technology in learning is still lacking. Technology has the opportunity to facilitate students' understanding of concepts in the era of the 4.0 industrial revolution. Hoyles and Lagrange cited by Putrawangsa [12] explain the influence of data technology on the education system in Indonesia, due to the factors of effectiveness, efficiency, and attractiveness offered by digital technology.

Based on the above background, a multi-representation-based e-physics module is being developed on the subject of momentum and impulses for high school/MA students. The e-modules developed can be accessed independently by both teachers and pupils using their respective Android devices.

B. Method

This research applies a Research & Development method, R&D. Sugiyono [13] explains that this research method produces a product and tests the level of effectiveness of a product. The development model in this study is a 4D model proposed by Thiagarajan. The model consists of four stages that include Define, Design, Develop and Disseminate. This research is limited to the stage. The

development model is restricted to the development stage, precisely the extensive trial.

The research was conducted at 08 Yogyakarta Public High School. The research subjects were the tenth graders. The trial run was two phases, a limited trial and a comprehensive trial. The limited test involved 10 students in X Mathematics Science 1 class, while an extensive test was carried out on 36 students of X Mathematics Science 2. The data collection methods were interviews, observations, and elevation of students' responses. Interviews were conducted to determine the needs of students and teachers in the implementation of learning. The observation was useful to determine the situation and conditions of learning in the classroom. The student response questionnaire was useful in determining the quality of the developed multi-representation-based e-module. The research instruments were the product and instrument validation sheets, e-module quality assessment sheets, and student response sheets.

Product and instrument validation data analysis was Aiken's V. The obtained coefficient value ranges from 0 to 1 and is adjusted to the validity level criteria. The product quality evaluation sheet uses the Likert scale with 4 evaluation scales. The obtained data on the assessment was then analyzed using a mean equation. The mean score was then converted based on the product quality assessment criteria. The student's response sheet uses the Guttman scale with two response scales. The obtained data on the student's response sheet was then analyzed using an average equation. The obtained mean score was based on calculations and then converted according to the criteria of student response. If the results show agreed criteria then the multi-representation-based e-physics module is eligible for further use in classroom learning.

C. Results and Discussion

At the Define stage, the analysis of necessity dealt with curriculum analysis, student analysis, material analysis, and school analysis. Based on the curriculum analysis, Yogyakarta Public High School 08 used the 2013 Curriculum in classroom learning. Prihadi [14] that the 2013 curriculum requires students to seek and learn the studied materials through a variety of sources and references. The analysis of the students showed that the students experienced difficulties with physical disabilities, especially in solving problems. Students thought that physics was full of mathematical equations and memorizations of mathematic equations without knowing the physical meanings.

In the analysis of the material, the applied learning media by the teacher in delivering the material as a board, PowerPoint, and worksheet but with limited presentations. In addition, the implementation of the laboratory in the learning

process was very low. The researchers found the laboratory equipment was full of dust as explained by the librarian. Students also stated that they had difficulties understanding the concept of the matter of momentum and impulses. For the learners, momentum, and impulses were associated with vectors in determining the direction of motion of objects. However, they did not understand vector material optimally. Then the last one on the obtained school analysis was the implementation of the study based on the vision, mission, and purpose of the school. In this case, Yogyakarta Public High School 08 aims to create a school with outstanding achievements in all fields, such as science and technology.

Therefore, the school authorities allow every student to carry electronic devices. The presence of this policy is expected that electronic devices brought to schools could be used wisely by learners during classroom learning. The design phase consisted of several activities such as product selection, design of e-module concepts, material design and evaluation tools, and the e-Module initial product.At the selection of the product, the researchers determined the relevant product to the analysis of the needs. In this case, the selected product is a multi-representation-based physics module on the subject of momentum and impulses. The developed e-module is accessible only with an Android device. The e-module took the form of a learning application on a gadget. This module contains learning material with a variety of representations and also simulations connected with PhET Simulation.

In the design of the e-module concept, the researchers mapped the e-Module design and determined the contents to present. At this stage, the researchers also started designing the UI and UX design of the e-module. During the planning of materials and evaluation tools, an identification of core competencies and basic competencies was done based on the 2013 curriculum. Subsequently, a mapping of representations such as verbal, graphic, mathematical, and graphic was useful for the learners to easily understand the material of momentum and impulses. Besides preparing the e-module concept, the researchers also arranged the instruments to evaluate the e-module.

At the beginning of the e-module product, the researchers began to compile e-modules based on a previous design. The module consisted of five matters: introduction, concepts of momentum and impulse, the law of momentum conversion, restitution coefficient, and types of impact. Each of the subjects was described using multi-representation methods to facilitate learners' understanding of the concept. In addition, the e-module also features a simulation of the impact using PhET Simulation both online and offline. The simulation may last directly inside the application without the assistance of third-party applications such as Chrome, explorer, etc. The e-module also had an evaluation feature consisting of 25 dual-choice issues to determine the learning achievements.

The second stage is the development stage. This stage included validation, evaluation, and also product testing. The researchers validated the research

instrument before further implementation. In this case, the researchers validated the instrument with two expert validators of the instrument. As for the Aiken index on the validation of instruments, the obtained score was 0.92 with a high validity criterion, indicating the readiness of the instrument for the research. The next stage is product development. This stage involved two experts: material and media experts. Figure 1 shows the product validation.

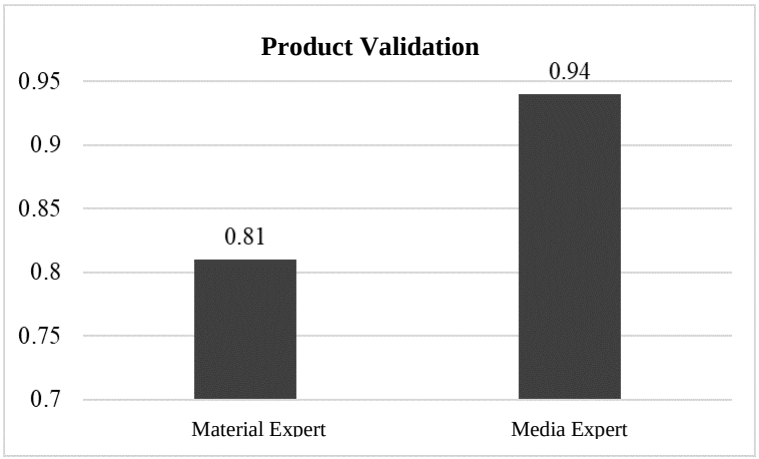

Figure 1. Product Validation Results

The figure shows the multirepresentation-based e-physics module has a "High Validity" criterion with a score of 0.81 for the material expert and 0.94 for the media expert. The values indicate that the e-module is excellent in terms of content and also presentation. In addition to providing validation scores, material experts and the media also provide suggestions and input as consideration for further revisions

The revision was the second version of the module to be assessed in terms of quality by the experts and the teachers. This assessment involved two material experts, two media experts, and two physics teachers. Figure 2 shows the assessment results of the developed module.

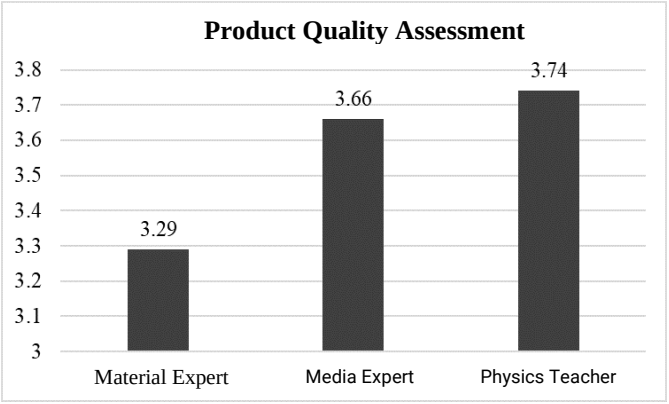

Figure 2. The Assessment Results of the Product Quality

The figure shows the developed module has the "Very Good" criterion with a score of 3.29 for materialists, 3.66 for media experts, and 3.74 for physics teachers. The values indicate that the e-module is excellent in terms of content and also presentation. Besides giving the assessment scores, the experts and teachers also shared suggestions and input as consideration for making improvements. Here is the recapitulation.

After revising, the researchers examined the revised version of the product. Product testing was useful to determine the student's response after using the module. The product trial run included two phases: limited trials and massive trials. The researchers obtained student's responses from a response questionnaire

The limited trial run involved 10 students from tenth grade. The limited test results got a score ratio of 1.00 with agreed criteria. The multi representation-based e-physics module on the language of momentum and impulses could facilitate the student's learning style in understanding the concepts of physics. The results of a limited trial show entire indicator on the multirepresentation aspect obtains a high percentage above 50%. Therefore, the developed product was appropriate and easy to understand by the learners. Students could easily understand material due to various representations such as verbal, graphic, mathematical, and graphic

Besides sharing the responses of the limited trial run, the learners also provided suggestions and input to the e-module. The respondents recommended a quiz review feature about the evaluation item answers for further learning. However, the researchers did not follow up on the recommendation because of the limited package of the features. This feature could not be modified so the researchers had to follow the features based on the software's articulate storyline.

After having the limited test, the researchers conducted a massive trial run for 36 learners from X Mathematics and Science 2. The limited test results got a score ratio of 0,95 with agreed criteria. The multi-representation-based e-physics module on the language of momentum and impulses could facilitate the student's learning style in understanding the concepts of physics. The analysis of the massive trial run found that

all indicators of multi-representation aspects had a high percentage, more than 50%. Therefore, the developed product was appropriate and easy to understand by the learners.

Besides that, the scoring responses of the massive trial run provided the opportunity for the learners to share suggestions and recommendations for the module. Here are some suggestions for the learners.

1. The researchers found errors in writing on the question example features.
2. The conclusion feature of impact simulation was not available.
3. The ratio aspect of the e-module needs optimization to provide a full-screen display on a smartphone.

Based on the massive trial run, the researchers also examined the implementation of the developed e-module. The implementation of the e-module was useful in determining the readability of the applied module in the learning. The developed e-module performance test scores a ratio of 3.5 with very good criteria. Based on the result, the multi-representation-based e-module physics is applicable as a physical teaching material for both high school/Islamic high school students in understanding the materials of momentum and impulses. Handayani [15] also explains the development of multi multi-representative physics e-module based on PBL for rigid objects. The researchers found the development obtained an extremely excellent criterion with a mean score of 89.49.

D. Conclusions

In this case, the selected product is a multi-representation-based physics module on the subject of momentum and impulses. This e-module uses the Android technology. The presented representations included verbal, figure, mathematical, and graphic representations. The quality of the developed module is excellent in facilitating the learning styles of High School and Islamic High School learners. The material and media experts and the teachers argued that the module is extremely excellent with a mean score of 3.29 for the material expert, 3.66 for the media expert, and 3.74 for the teachers. The obtained responses from the trial run include two parts: the limited and massive tests. The limited test involved 10 learners of tenth grade. The responses to the limited test obtained a score of 1 with the category of agree. The massive test involved 36 learners of X Mathematics and Science 2. The responses to the massive test obtained a score of 0.95 with the category of agree.

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