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Science Process Skills Test Instruments in The New Indonesian Curriculum (Merdeka): Physics Subject in Renewable Energy Topic

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ABSTRACT

The physics subject in the Merdeka Curriculum is organized into two categories, understanding physics and process skills. The physics process skills assessment instruments used by teachers in the field are not appropriate in terms of assessment methods and the assessment tends to be subjective. This study aims to develop a science process skills test instrument in physics learning for high school students, on the topic of Renewable Energy. The method used in this research is development research. The instrument was developed with the Extended Written Response method, essay-type questions consisting of fifteen written test items. Indicators of science process skills developed are observing, questioning and predicting, planning and conducting investigations, processing, analyzing data and information, creating, evaluating and reflecting, and communicating. The stages of developing this test instrument are making indicators of questions, making questions, judgments by topic experts and assessment experts, revising questions, testing, revising questions, and implementing questions at school. The results showed that the test instrument developed was suitable for use as a process skills test instrument on the Renewable Energy topic.

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1. INTRODUCTION

Physics is the branch of science that studies the properties of matter in space and time and the related concepts of force and energy. Physics objectively and quantitatively examines the scientific inferences involved in the process of observing, measuring, and modeling the relationships between relevant variables that reflect the laws of nature and drawing inferences that are implemented into valid and applicable theories. By applying it, we study natural phenomena from the atomic scale to the universe.

The physics learning process in Merdeka Curriculum trains students to make simple investigations of natural phenomena. Students will learn to identify problems, form hypotheses, design simple experiments, conduct experiments, analyze data, draw conclusions, and communicate experimental results in writing and orally (see https://guru.kemdikbud.go.id/kurikulum/referensi-penerapan/capaian-pembelajaran/sd-sma/fisika/).

Kemendikbudristek (2022) stated that physics is taught as a specialized subject separate from science (very different from junior high school) at the senior high school level. First of all, a correct and deep understanding of physics will help us solve everyday problems. Second, strong scientific process skills are the bridge to students' success in pursuing graduate studies in both basic/physical sciences and engineering and technology.

Through observation of physics learning at one of the senior high schools implementing the First Batch Penggerak School Program in a district in Riau Province, it was concluded that the process skills of students in the high school were still low in the aspects of (1) observing, (2) questioning and predicting (3) planning and carrying out investigations, (4) processing and analyzing data and information, (5) creating (6) evaluating and reflecting and (7) communicating the results, as seen in the odd semester learning outcomes of grade X students in the 2022/2023 Academic Year.

This, after being traced, turned out to be due to the teacher's inaccuracy in choosing the physics process skills assessment method. Thus, students' process skills were not properly accommodated when assessed and tended to be subjective in their assessments. Based on the findings in the field, several solutions are expected to be effective and targeted to help solve these problems, namely providing a reference in the form of choosing the right assessment method to assess students' process skills and developing a process skills test instrument that can be a reference for physics teachers for use in learning.

The instrument topic to be developed is Renewable Energy because it is one of the topics contained in the even semester which has not been optimally assessed in research target schools. Renewable energy education is expected to play an important and effective role in promoting sustainable development and improving the quality of life for a large portion of the world's population.

Policymakers need to be aware of the latest advances in renewable energy and their benefits and potential to provide sustainable energy supply options to meet the global energy surge (Kandpal & Broman, 2014). Renewable energy in Indonesia is contained in the content structure of the independent curriculum in phase E class X. Therefore this study aims to develop a science process skills test instrument that is oriented to Merdeka Curriculum.

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2. THEORY

2.1. Science Process Skills

Science is an experiment-based discipline, where science experiments are the core activities in science learning. Mastery of science process skills is needed in these science experiments. Thus, students are accustomed to using scientific methods and deepening their knowledge (Idris *et al*., 2022).

Science is an integration of process, product, and scientific attitude aspects. The process of science occurs when science process skills for the discovery of science products in the implementation of scientific activities (Prayitno *et al*., 2017). The scientific process skills that learners need to master range from the simplest skills, such as observation and measurement, to the most advanced skills, such as the ability to experiment. The ultimate goal of scientific learning, therefore, is to acquire the comprehensive skill of inquiry, and the ability to conduct experiments and observations to discover scientific concepts.

Science process skills consist of basic science process skills and integrated science process skills (Elvan *et al*., 2010). Basic scientific process skills, including observing, questioning, classifying, measuring, and predicting. The second group consists of integrated scientific process skills. This includes identifying and defining variables, collecting and transforming data, creating data tables and graphs, describing relationships between variables, interpreting data, manipulating materials, recording data, developing hypotheses, designing investigations, making inferences, and generalizing (Karamustafaoğlu, 2011). The acquisition of science process skills by students plays a crucial role in facilitating their learning (Nurulia, 2021).

Scientific and engineering skills are integrated skills that are included in the process skills to be developed in the Merdeka Curriculum, which includes several scientific activities, namely observing, questioning and predicting, planning and conducting investigations, processing and analyzing data and information, creating, and evaluating and reflecting and communicating results.

The science process skill assessment is an effective way to test student achievement or skill and provide feedback to teachers on student performance. Assessment should be flexible and simple so that it can be conducted individually, in small groups, or as a whole class. More importantly, it meets the needs of teachers and students.

2.2. Renewable Energy

A renewable energy source is an energy source that will never run out because it can be replaced by natural processes within a period comparable to the amount used. Energy from renewable sources is called renewable energy. Renewable energies have eco-friendly properties and are endless, including solar, wind, hydro, geothermal, and bioenergy. Expensive to develop, but relatively cheaper than non-renewable energy in the long run.

The sun is the largest source of energy in the universe. Solar energy is generally available in two ways: solar cells and solar heat. Solar cells can convert solar energy directly into electrical energy, while solar heat is used as a water heater.

Solar energy may be the best option for the future world for several reasons, because first, solar energy is the most abundant source of renewable energy, the sun emits solar energy with its output of 3.8×10^{23} kW, of which about 1.8×10^{14} kW is absorbed by the earth (Panwar *et al*.,2011). Solar energy reaches the earth in various forms such as heat and light. As this energy propagates, much of its contribution is lost through scattering, reflection, and absorption by clouds.

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Studies show that solar energy is abundant in nature and a freely available energy source at no cost. Thus, the full use of solar energy can meet the world's energy needs (Lewis, 2007). Second, it is a promising energy source in the world because it is inexhaustible and offers reliable and high production efficiency compared to other energy sources (Nozik, 1978).

Wind energy sources are infinitely available in nature and can be used as an alternative to non-renewable energy sources as the acquisition of wind turbines is environmentally friendly. Harnessing the wind to generate electricity by rotating the rotor blades of a wind turbine is known as wind energy or wind power (Demirbaş, 2006).

Renewable energy from the wind has been used for centuries to power windmills for grinding wheat and pumping water. More recently, large wind turbines have been developed to help generate electricity. This energy source is environmentally friendly and freely available in many areas. Wind turbines are becoming more efficient. The cost of the electricity they generate is going down.

Water can also be used as an alternative energy source, such as through the purchase of hydroelectric power plants, as the existence of the water cycle provides an infinite supply of water. Based on Energy and Natural Resources Ministry (ESDM) data, Indonesia's hydropower potential (PLTA) is 75,000 MW. Solar energy is our most direct renewable energy source. This energy can be used for solar heating (SH), solar home heating (SHH), solar dryers (SD), solar cookers (SC), solar water heaters (SWH), solar power (SPV: direct conversion of sunlight into electricity) and solar thermal electricity (STEP: when the sun's energy is concentrated to heat water and produce steam that is used to generate electricity) (Demirbaş, 2006).

Geothermal Energy (GE) possesses untapped potential as a non-carbon renewable energy source that can effectively contribute to addressing the challenges of climate change (Jorgenson *et al*., 2019). Geothermal energy offers benefits beyond electricity generation in various plant setups. It can also be directly utilized for heat applications in industrial and household settings, irrespective of weather conditions (Moya *et al*., 2018).

Bioenergy is a renewable energy source obtained from organic raw materials. Bioenergy can typically produce three types of energy sources: biomass, biofuel, and biogas. Biomass is all organic matter derived from plants, trees, and crops and essentially refers to the collection and storage of solar energy through photosynthesis.

Biomass energy (bioenergy) is the conversion of biomass into useful energy forms such as heat, electricity, and liquid fuels (biofuels). Biomass for bioenergy comes either directly from the land, such as special energy crops, or from the residues of crop processing for food and other products (Srirangan et al., 2012). Climate change requires a broad social transition from a centralized, fossil fuel-based energy system to a renewable energy system (Jorgenson *et al*., 2019).

The recent agreement on climate change in Paris underscores the urgent need to aggressively reduce carbon emissions in the energy sector and create environmentally friendly technologies, particularly for generating electricity. To tackle this challenge, it is essential to adopt a multifaceted approach that encompasses research, education, and informed public discussions. Consequently, it is necessary to introduce new and comprehensive educational initiatives focused on sustainable energy technologies at both university and potentially high school levels (Nowotny, 2018).

3. METHODS

This research was conducted at one of the Penggerak High Schools in Riau Province, with a population of Grade XI students in the Even Semester of the 2022-2023 Academic Year. Through purposive sampling, the sample in one grade was 20 people consisting of 3 boys and

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17 girls. The research was conducted for seven months from early October 2022 to early May 2023. The method used in this research is the design-based research (DBR) method. The stages of developing this test instrument are making indicator questions, making questions, judgments by 7 experts, revising questions, testing, revising questions, and implementing questions at school. However, in this study, it was only carried out until the trial stage. This is due to limited time.

The results of expert validation are then processed using the Content Validity Ratio (CVR) formula developed by Lawshe. CVR is a content validation approach to determine the suitability of test items with components measured based on expert judgment (Wilson *et al*., 2012). The minimum CVR value for the variation in the number of experts is presented in **Table 1**.

The results are then interpreted to determine the validity category based on **Table 2**. The results of the test items were analyzed using the Rasch model utilizing the Winstep Rasch application to determine item validity, reliability, item difficulty level, and discriminating power. Item validity can be determined by examining item fit, namely the suitability of the item with the model. An item can be said to have a suitability item (item) if the following parameters in **Table 3**.

Table 1. Minimum CVR value for variations in the number of experts (Wilson et al., 2012).

Number of experts	Minimum CVR value	Number of experts	Minimum CVR value
5	0.736	13	0.456
6	0.672	14	0.440
7	0.622	15	0.425
8	0.582	16	0.368
9	0.548	17	0.329
10	0.520	918	0.300
11	0.496	19	0.287
12	0.475	20	0.260

Table 2. CVR score categories (Ayre & Scally, 2014).

CVR score range	Category
0.68 – 1.00	Very Suitable
0.34 – 0.67	Suitable
0.00 – 0.33	Not Suitable

Table 3. Item fit parameters/item fit (Adi *et al*., 2022).

Parameter	Received Value
Outfit Mean Square (MNSQ) value	0.5 < MNSQ < 1.5
Outfit Z-Standard (ZSTD) value	-2 < ZSTD < +2
Point Measure Correlation (Pt Measure Corr) value	0.4 < *Pt Measure Corr* < 0.85

An item has very good item suitability if the MNSQ, ZSTD, and Point Measure Correlation scores obtained are in the acceptable score range. items can still be accepted (not changed) if they meet at least one of these parameters. However, items are considered inappropriate (outliers or misfits) if they do not meet these three parameters.

Thus, the item needs to be changed or replaced. Reliability in this study will be analyzed through the Rasch model with Ministep software, by observing Cronbach's Alpha value which is a picture of the quality of the interaction between respondents and items. The reliability

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value and Cronbach's Alpha value can be seen in the Output Tables: Summary Statistics. The interpretation of the reliability value and Cronbach's Alpha (Perera *et al*., 2018) is shown in **Tables 4** and **5**. The difficulty level of the items can be observed through the Output Tables: Item Measure. The items in the Entry Number column are sorted from the largest logit value to the smallest logit value. The logit value in the JMLE Measure column indicates the difficulty level of the problem, with the interpretation that the higher the logit value, the higher the problem difficulty, and vice versa.

The item measure column also contains information on the standard deviation value. Through the standard deviation value and the average logit value (in the JMLE measure column), the level of difficulty of the items can be grouped. A value of 0.00 logit +1 SD is a difficult category, greater than +1 SD is a very difficult category, 0.00 logit -1 SD is an easy category and less than -1 SD is a very easy category (Laliyo *et al*., 2022).

Data on the results of the test for discriminating power of questions can be seen in the Output Tables: Item Fit. The MNSQ and ZSTD values are then taken into consideration in determining whether the items are valid or invalid, while the Point Measure Correlation values are analyzed to determine their distinguishing power. An interpretation guide for Point Measure Correlation values is presented in **Table 6**.

Table 4. Interpretation of the value of person reliability and item reliability in the Rasch model analysis.

Reliability Coefficient	Category
Value > 0.94	Special
0.91≤ Value ≤ 0.94	Very good
0.81 ≤ Value ≤ 0.90	Good
0.67 ≤ Value ≤ 0.80	Enough
Value < 0.67	Weak

Table 5. Interpretation of Cronbach's alpha values.

Item Reliability Coefficient	Category
α ≥ 0.8	Very good
0.7 ≤ α < 0.8	Good
0.6 ≤ α < 0.7	Enough
0.5 ≤ α < 0.6	Not enough
α < 0.5	Very less

Table 6. Interpretation of point measures correlation values (Perera *et al*., 2018).

Discriminating Power	Interpretation
PT-Measure Corr. > 0.40	Very good
0.30 < PT-Measure Corr. ≤ 0.40	Good
0.20 < PT-Measure Corr. ≤ 0.30	Enough
PT-Measure Corr. ≤ 0.20	Not enough (bad)

4. RESULTS AND DISCUSSION

The results of the development were in the form of a Renewable Energy topic process skills test instrument at the high school level in the form of essay questions totaling 15 questions with 7 indicators of science process skills. The process skills test instrument grid is presented in **Table 7**.

Table 7. Process skills test instrument grid.

Aspects of Process Skills	Process Skills Sub Aspect	Indicators of Learning Objectives Achievement	Question Item Number	Number of Items
Observing	Observing	Write down the results of observations on the problem of energy availability in one of Indonesia's regions.	1	1
Questioning and Predicting	Questioning	Write relevant questions regarding the potential for renewable energy in one of Indonesia's regions.	2	3
		Formulate the problem of renewable energy potential in one of Indonesia's regions.	4	
	Predicting	Predicting the potential for renewable energy in one of Indonesia's regions.	3	
Planning, Conducting, and Investigating	Planning	Identify the background of the problem of investigating the working principle of a renewable energy power plant.	5	3
		Write the formulation of the purpose of investigating the working principle of a renewable energy power plant.	6	
	Conducting and Investigating	Write down the work steps and methods of collecting data to investigate the working principle of a renewable energy power plant.	7	
Processing, analyzing data, and information	Processing, analyzing data, and information	Processing, analyzing data, and information regarding the advantages and disadvantages as well as obstacles to the development of one of renewable energies.	8	2
		Write down data and information references regarding the advantages and disadvantages as well as obstacles to the development of one of renewable energies.	9	
Creating	Creating	Creating a renewable energy development design.	10	1
Evaluating and reflecting	Evaluating	Write down critical questions on the results of research and/or design for renewable energy development.	11	3
		Writing scientific arguments against the results of investigations and/or designs for renewable energy development.	12	
	Reflect	Write down recommendations for improvements to the results of investigations and/or designs for renewable energy development.	13	
Communicating	Communicating	Communicate the results of the research and/or design for the development of renewable energy in the form of a concept map.	14	2
		Write appropriate conclusions to answer problems related to renewable energy potential in a particular area.	15	
			Total Number of Question Items	**15**

Learning objectives are the following:

(i) Observing the problem of energy availability in one of Indonesia's regions.
(ii) Questioning and predicting the potential for renewable energy in one of Indonesia's regions.
(iii) Plan and carry out investigations regarding the working principle of a renewable energy power plant.
(iv) Processing, and analyzing data and information regarding the advantages and disadvantages as well as obstacles to the development of one of the renewable energies.
(v) Creating a renewable energy development design.
(vi) Evaluate and reflect on the results of investigations and/or designs for renewable energy development.
(vii) Communicating the results of research and/or designs for renewable energy development.

Assessment Method : Extended Written Response
Question Type : Essay Items

After creating the skills test questions, the next step is to conduct an instrument judgment by an expert using a process skills validation sheet. The results of expert validation are presented in **Table 8**.

Table 8. Recapitulation of content validation results by expert validators.

Question Item Number	Question Code	Conclusion of Expert Judgment on Process Skills Test Items		
		Worth using without revision	Worth using with revisions as suggested	Not worth using
1	E1	4 expert validator	3 expert validator	-
2	E2			
3	E3			
4	E4			
5	E5			
6	E6			
7	E7			
8	E8			
9	E9			
10	E10			
11	E11			
12	E12			
13	E13			
14	E14			
15	E15			

The CVR calculation gets a score of 1 so that the validity of the content is included in the very appropriate category. The next step is to revise the questions based on suggestions for improvement from the validators. The revised questions were then tried out in one grade that had studied the Renewable Energy topics. The grade consists of 20 students. The test results that have been analyzed using the Rasch model are presented in **Table 9**.

The research that has been carried out at this time has only reached the first stage of testing questions and has not yet been tested and revised in the second stage of questions, so questions with very easy and very difficult levels do not appear and no different power results appear that are not worth enough (bad).

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In **Table 9**, all questions are valid and reliable, but the question coded E1 (item number 1) has discriminating power in the insufficient (bad) category with a Pt Measure Corr value of 0.16 so item E1 needs to be revised before being used. Likewise, the question coded E14 (item number 14) has discriminating power in the insufficient (poor) category with a Pt Measure Corr value of -0.03 so that item E14 cannot be used or can be used but must be revised.

The results of the development were in the form of a Renewable Energy topic process skills test instrument oriented to Merdeka Curriculum at the high school level in the form of essay questions totaling 15 (fifteen) questions with 7 indicators of science process skills, all of the fifteen process skills test questions are appropriate for use to measure process skills in renewable energy topic.

Table 9. Summary of test results for validity, reliability, level of difficulty, and differentiating power.

Question Item Number	Question Code	Content Validity	Validity Item	Reliability	Difficulty Level	Discriminating Power	Decision
1	E1	Valid	Valid	Reliable	Very easy	Not Enough (Bad)	Worth using with revision
2	E2	Valid	Valid	Reliable	Very easy	Very Good	Worth using
3	E3	Valid	Valid	Reliable	Very easy	Very Good	Worth using
4	E4	Valid	Valid	Reliable	Easy	Very Good	Worth using
5	E5	Valid	Valid	Reliable	Difficult	Very Good	Worth using
6	E6	Valid	Valid	Reliable	Easy	Very Good	Worth using
7	E7	Valid	Valid	Reliable	Very Difficult	Very Good	Worth using
8	E8	Valid	Valid	Reliable	Very Easy	Very Good	Worth using
9	E9	Valid	Valid	Reliable	Very Difficult	Very Good	Worth using
10	E10	Valid	Valid	Reliable	Very Difficult	Very Good	Worth using
11	E11	Valid	Valid	Reliable	Very Easy	Very Good	Worth using
12	E12	Valid	Valid	Reliable	Very Difficult	Very Good	Worth using
13	E13	Valid	Valid	Reliable	Easy	Very Good	Worth using
14	E14	Valid	Valid	Reliable	Easy	Not enough (bad)	Worth using with revision
15	E15	Valid	Valid	Reliable	Very Difficult	Very Good	Worth using

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5. CONCLUSION

Based on the research that has been carried out, it is concluded that Merdeka Curriculum-oriented science process skills test instrument has been developed for grade X students (phase E) on the Renewable Energy topic. This instrument used the Extended Written Response assessment method and Essay items question type accompanied by an answer assessment rubric.

The instrument consists of 15 (fifteen) question items that have been tested valid by expert validators and are reliable to test aspects of students' science process skills in the Merdeka curriculum, namely observing, questioning and predicting, planning and conducting investigations, processing, analyzing data and information, creating, evaluating and reflecting, and communicating.

The test instrument was made in the form of an essay to measure complex learning outcomes and access more detailed information about students' thinking processes in answering questions, especially in the aspects of processing, analyzing data and information, and creating. The results showed that the test instrument developed was suitable for use as a process skills test instrument on the Renewable Energy topic.

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7. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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