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Research Paper

Rasch Model Analysis: Cases Study in SDGs Trend Point 7 in Physics Learning Based Domicile

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Abstract

The low level of environmental awareness among the younger generation, particularly the understanding of the importance of clean and affordable energy, is a serious challenge to the desired efforts. This research aims to explore the understanding and motivation of high school students related to clean and affordable energy sources, in accordance with the 2030 Sustainable Development Goals (SDGs). The results of Rasch model analysis show that students' understanding of clean energy varies, with students in urban areas having better access to information compared to students in districts. There are differences in understanding based on gender, female students tend to have difficulty understanding energy problems than male students. Female students tend to be more motivated in clean energy and environmental issues, while male students have a stronger understanding of sustainable technology. Real projects and interactive materials that connect clean energy with daily life through physics learning motivate learners. These findings underscore the importance of inclusive and project-based education to increase student awareness and participation in supporting the achievement of the 2030 SDGs in sustainable physics learning.

Keywords: Clean energy; domicile; Physics; SDGs 2030.

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1. Introduction

The Industrial Revolution, which began early 18th century to the present, has Obtain consistent upward changes transformations in the way humans produce goods and use energy (Adiyoso, 2022). Technological developments and innovations in production processes have significantly increased efficiency and productivity, enabling mass production of goods and greater energy consumption. However, these advances have also had a major environmental impact, especially through increased fossil energy consumption (khan et al., 2022). This negative impact demands attention and efforts to reduce dependence on fossil energy and switch to more environmentally friendly energy sources. The use of fossil fuels such as coal, oil, and gas has led to high greenhouse gas (GHG) emissions (Gurría, 2021). All types of non-renewable energy are a source of power in today's life and technology. This effect causes high dependence on the massive use of natural resources such as oil and coal.

More than half of the nation's electricity is generated by coal. Burning coal produces substantial carbon emissions, contributing to global climate change and contradicting efforts to switch to renewable energy (Rudiyanto, 2016). Burning coal releases carbon emissions that can exacerbate the effects of climate change. When released into the atmosphere, carbon dioxide (CO2) functions as a greenhouse gas, intensifying the consequences of global warming. That raises the earth's temperature, which leads to drastic weather patterns, including heat waves, droughts, and floods. In addition, rising emissions endanger the sustainability of food supplies, harm ecosystems, and raise the frequency of natural disasters. The long-term effects of these emissions may result in irreversible harm to the environment and society, which would further impede attempts to transition to greener energy sources. Furthermore, extraction-related air pollution and environmental deterioration have had detrimental effects on ecosystems and human health (Lestari, 2024).

The United Nations' 2030 Sustainable Development Agenda highlights the significance of moving toward affordable and clean energy as one of the Sustainable Development Goals (SDGs) to address these issues. This SDG objective guarantees universal access to modern, affordable, dependable, and sustainable energy. As part of the energy transition, this entails encouraging renewable energy sources like solar, wind, and biomass while lowering reliance on dirty fossil fuels like coal and oil. Adopting clean energy is expected to improve people's quality of life, particularly in places that did not previously have sufficient access to electricity, while lowering greenhouse gas emissions, lessening the effects of climate change, and creating new, sustainable jobs. In addition, using clean energy lessens adverse environmental effects and promotes long-term energy security. With a focus on "Clean and Affordable Energy," Point 7 of the SDGs seeks to reduce excessive use of fossil fuels and expand access to clean energy globally, which will spur the use of renewable energy (Lestari, 2024). These initiatives are essential to lessening the effects of climate change and building a more sustainable future (Bappenas, 2019).

The shift to renewable energy presents many difficult obstacles for Indonesia, a developing nation with a growing population (Walid Siagian et al., 2023). Despite Indonesia's potential, particularly in solar, wind, biomass, and other renewable energy sources, its use is still minimal compared to the country's growing energy demands (Walidi, 2021). Furthermore, there is still a significant reliance on fossil fuels, and the infrastructure and regulations have not adequately facilitated a swift and efficient transition (IESR, 2023). The lack of infrastructure to support renewable energy, particularly in rural and isolated locations, is one of the biggest obstacles. Furthermore, current regulations favor the fossil fuel sector, and fossil energy subsidies remain substantial. Although they need significant funding and more robust governmental support, transition measures like constructing renewable energy plants and decarbonization programs are beginning. The requirement to provide everyone with affordable and dependable energy access while hastening the shift to a more sustainable energy system makes this problem even more difficult.

In this energy transition endeavor, the younger generation—particularly high school students—plays a critical role. The younger generation is searching for identity through skill development. As change agents, the younger generation has enormous potential to shape the course of society's evolution through social action, innovation, and creativity. They have also emerged as key players in social movements in this age of globalization and digitization, particularly those about social justice, equality, climate change, and technical advancement. A better and more sustainable society mostly depends on a younger generation that is informed, capable, and conscious of global issues. They are the next generation that will determine the direction of future energy policy (Azomahou & Yitbarek, 2016). However, their motivation and understanding of clean energy are often not optimal.

This lack of motivation is due to a lack of environmental awareness among the current generation. Environmental awareness theory emphasizes the importance of individual knowledge, attitudes, and concern for environmental issues as the basis for developing sustainable, environmentally conscious behavior (Kousar et al., 2022). In reality, today's younger generation lacks environmental awareness theory and motivation to understand clean and affordable energy (Varga & Csiszárik-Kocsir, 2024). However, with high environmental awareness, adequate knowledge about clean energy sources can foster critical awareness and active student participation in efforts to create a sustainable environment, despite differences in access to information, regional background, and gender. Furthermore, research shows that a lack of understanding of the importance of clean energy, as well as its impact on life and the environment, can hinder their active participation in supporting the 2030 SDGs (Räty & Carlsson-Kanyama, 2010). Lack of literacy also has an impact on understanding current environmental issues and their impact on life (Durmuş & Kınacı, 2021), apart from knowing the role and abilities of today's young generation. In equalizing living conditions and housing, efforts to determine the understanding ability of the younger generation in clean and affordable energy will certainly have a certain level of difference, influenced by where they live or domicile.

Factors such as domicile (city vs district) and gender also affect the level of understanding and participation of students in clean energy issues (Tran & Le, 2024). In urban areas, access to information and education may be better, while in rural areas, limited resources and information can hinder understanding (Chen et al., 2024). This is the main reason that these differences can occur. Apart from easy access to information, more accurate, quality information is more likely to be obtained in urban areas. However, the natural situations found in many villages have the advantage of providing the younger generation with knowledge about clean and affordable energy. Therefore, looking at all the existing possibilities, it can be analyzed as a novelty in comparing the younger generation's understanding of their respective domiciles (Parwati et al., 2020). Apart from analyzing differences in domicile, gender differences can also be identified for each student. The selection of the young generation was carried out by remembering that the current young generation is the hope in creating clean energy efforts today, especially students who are still in the development stage (Yamane & Kaneko, 2021).

Gender differences can also influence attitudes and engagement in clean energy issues, with social and cultural factors playing an important role in shaping those attitudes (Tandrayen-Ragoobur, 2024; Zempi & Awan, 2017). Gender differences can influence individual attitudes and involvement in clean energy issues due to social and cultural factors that shape roles and views towards the environment and sustainability. Gender roles have historically shaped people's perceptions of and interactions with technology, particularly renewable energy (Standal et al., 2020). Men's and women's cognitive and emotional abilities impact this disparity. Identifying and comprehending students' desire for clean and inexpensive energy, as well as distinctions based on gender and place of residence, is crucial for creating a successful educational strategy (UNDESA, 2014). A responsive, locally grounded curriculum can raise students' understanding and motivation to support the shift to clean energy (Albrizio et al., 2014; Ilham et al., 2021); (Irving et al., 2020). This study aims to investigate and evaluate how comprehension, gender- and domicile-based understanding disparities, and student motivation can support the attainment of the 2030 SDGs, particularly point 7 (Kuswanto & Anderson, 2021; Marulanda-Grisales & Vera-Acevedo, 2022).

In addition to being significant for clean energy education, this research is also pertinent for raising a younger generation that is more conscious of and involved in international initiatives to combat climate change and the energy issue (Alfathy et al., 2024; Nugroho, 2021). Particularly when considering Indonesian education policy and renewable energy education, this study significantly adds to existing knowledge (Sambodo et al., 2022). This study offers a fresh viewpoint on assessing the efficacy of renewable energy education by applying the Rasch model to examine students' comprehension of clean and inexpensive energy. The findings of this study can shed further light on how students' knowledge varies depending on their gender and place of residence, which is crucial for creating inclusive teaching methods that consider local needs (Alazeez et al., 2024). The research findings offer important information for creating more successful curricula and teaching methods that can aid international initiatives to establish national sustainable development goals. Thus, this research contributes to the theoretical understanding of renewable energy education literature and has significant practical implications for education policy and energy transition strategies in Indonesia.

2. Methods

This study employs a quantitative descriptive approach to analyze high school students' understanding of clean and affordable energy in physics learning using the Rasch model. Through quantitative research with numerical data presentation, the Rasch model is used to describe the quality of the instrument (validity, reliability, item difficulty level, respondent ability) statistically (Prasetiyo et al., 2022). The research was conducted by averaging the scores of each assessment result eligibility criterion determined based on the level of suitability (Percentage of Agreement) of the instrument (Chan et al., 2021). The use of the Rasch model in quantitative descriptive research allows researchers to present a valid and reliable empirical picture based on strong mathematical analysis.

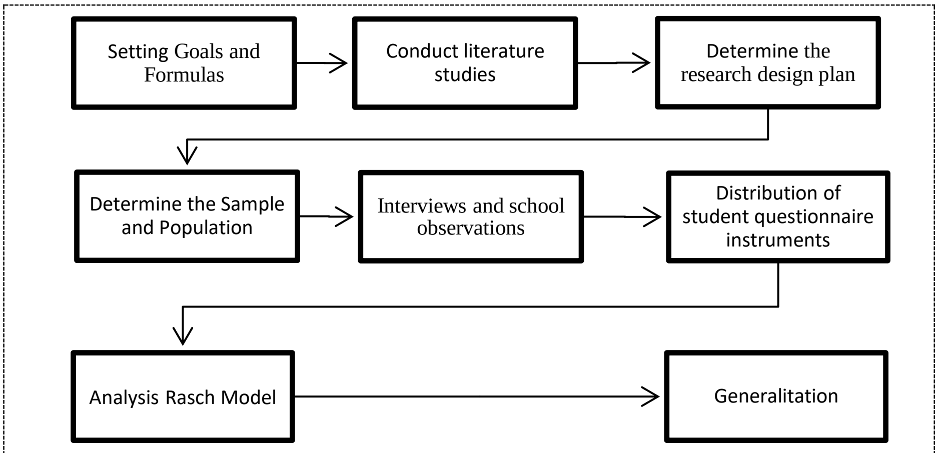

Figure 1. Research Design (Habibbulloh, 2017; Muslihin, 2022)

Data from observations and interviews with the school will support the findings of the questionnaires that were provided to the kids. A Schnell model with specific criteria was used to examine these findings. Because it can provide accurate and unbiased assessments of students' abilities, the Rasch model has grown important as an analytical tool in education (Almubarak & Saadi, 2022). This methodology considers each question item's difficulty, enabling researchers to gauge students' comprehension levels more accurately. The Rasch model is beneficial in clean energy education because it can assess how students from various backgrounds—such as gender and place of residence (rural versus urban)—understand the idea of renewable energy.

The Rasch model can be used to successfully discover disparities in students' comprehension and create teaching tactics that better meet their requirements, according to earlier research, such as that done by Bond and Fox (2015). The application of the Rasch model in scientific education to assess curriculum efficacy and the impact of demographic factors on learning outcomes was highlighted in another study by Boone et al. (2014) (Syahputra et al., 2023). Thus, the Rasch model's implementation in this study can promote the creation of more successful educational practices by offering more precise and organized insight into the variables influencing students' comprehension of renewable energy.

Questionnaires were used to collect data, and the Rasch model was used for analysis. The population used in distributing the questionnaires was students at secondary schools with different domiciles (City and Regency). The sample was determined through purposive sampling by selecting one school for each criterion, namely SMA I Cerme (Regency) and SMA Takmiriyah Surabaya (City). The questionnaire uses a Likert scale with 4 (four) answer choices: strongly agree, agree, disagree, and strongly disagree. It was distributed via Google Forms and analyzed using the Rasch model.

Table 1. Student Questionnaire Results

Rating Scale	Criteria
4	Strongly Agree
3	Agree
2	Disagree
1	Strongly Disagree

Item suitability testing can be done by determining the code for each question in the questionnaire first. Then it is interpreted through the results of whether a statement is valid or invalid. The data that has been entered into WinSteps is then analyzed to determine the size of the logit to show the respondent's tendency to fill out the questionnaire. Per-item logit (Measure) measurements can be carried out by knowing the MNSQ infit and MNSQ outfit values , which tend to be valid if they are close to the value 1. Meanwhile, the Z-STD infit and Z-STD outfit values tend to be valid if they are close to the value 0.

From the results of data interpretation, a scale can be decided to determine the validity of the instrument items, whether they can be understood by respondents well or not, through the Rating Scale of the following person measure values:

Table 2. Validitas dan Reliabilitas

Interval Scale pada Winstep / Ministeps	Criteria	Nilai Cronbach Alpha	Criteria
4 *s* < 0,10	Very Invalid	**< 0,5**	Less
0,10 ≤ *s* < 0,50	Invalid	**0,5 - 0,6**	Sufficient
0,50 ≤ *s* < 1,0	Valid	**0,7 - 0,8**	Good
1,00 ≤ *s*	Very Valid	**> 0,8**	Very Good

Validity and reliability values can be obtained using Cronbach's alpha values, with the aim of knowing the interaction between the person and the item as a whole. From the results of data processing using a Likert scale, the differences in results for each question were obtained.

3. Results and Discussions

3.1 Result

Based on research conducted on two schools with different domicile categories, the results of the questionnaire were obtained as follows,

Table 3. Student Questionnaire Results

Code	Question	Average	
		City	Regency
1A	As you can see, the energy of solar panels will not run out and has a good impact on health	4	4
2A	The use of coal as a source of electrical energy can add to pollution	3.8	4
3A	Electric vehicles are a new breakthrough for environmentally friendly activities	3.2	2.8
4A	The use of natural resources around me is one of the strategies to create a clean and affordable energy source	2.8	2.6
5A	Nuclear power plants are an alternative to clean and affordable energy as a source of electricity around the world	3.4	3.0
6A	In your opinion, is it important to utilize clean and affordable energy sources to get to a golden Indonesia?	4	3.2
7A	With the use of clean energy, economic growth will increase	4	3.8
8A	Clean and affordable energy is a strategy that can be easily done in this modern era with students as the main actors.	2.8	2.2
9A	The use of clean and affordable energy can be done in schools through the SDGs 7 program with the local village/city government.	3.2	3.0
10A	In physics learning, I can understand about clean and affordable energy	4	3.8
11A	I can create eco-friendly energy through physics learning	2.8	2.2

Code	Question	Average	
		City	Regency
12A	Physics learning provides a view of ideas for the realization of the use of clean and affordable energy	3.2	2.8
13A	My teacher always provides trending problems related to clean and affordable energy when learning physics	3.8	3.0

The value of the questionnaire results was obtained from the overall average result using a Likert scale of 1-4, with the provision that the larger the indicator (Afroz & Ilham, 2020), the closer the indicator strongly agreed with the statement given. From the distribution above, the questionnaire scores are calculated based on the average scores from the two domiciles of the students. The two domiciles explain their respective abilities with different average values.

From the results of the questionnaire, the validity value was obtained according to the category of measurement of each item through the INFIT value of MNSQ and the MNSQ outfit close to the value of 1, and the INFIT value and OUTFIT of ZSTD tended to be valid if it was close to the value of 0 (Azizah et al., 2020) as follows,

Table 4. Validity of the Questionnaire.

Class	*Infit*		*Outfit*		Score Validity	Information	Validity
	MNSQ	ZSTD	MNSQ	ZSTD			
City	1.00	-0.2	1.00	-0.1	1.20	Parameters met	Very Valid
Regency	1.00	0	1.01	-0.1	0.52		Valid

The data was distributed validly by knowing the difference in treatment in the two classes in two different schools. The results of the analysis utilizing the Rasch model analysis show that the reliability in the distribution of the questionnaire is maximum, or the data is reliable (Saputra et al., 2023). Another meaning that the data used is valid is that the data obtained has data indicators that meet the requirements for further analysis. Validity criteria are also referred to as pre-requisite tests in certain research.

Table 5. Reliability of the Questionnaire.

Class	*Cronbach Alpha*	Criteria
City	0.79	Sufficient
Regency	0.82	Sufficient
Total	0.85	Very good

Simple analysis of reliability results of each class item has a value of > 0.5 and is declared to meet reliable standards (Idrus et al., 2023), with the entire number of students in the city and district classes having a score in a very good category. From the previous pre-requirement test, the next Rasch model analysis is the identification of the Wright map in *WinStep* software to determine the measure order, in the analysis of the difficulty level of students from the type of questions given through the questionnaire.

Table 6. Item Scores in the Wright Map Based on Measure Order Questionnaires.

Number question	Score *Measure Order*
A1	39.03
A2	45.29
A3	48.82
A4	51.80
A5	49.97
A6	49.28
A7	48.59
A8	61.20
A9	54.28
A10	49.97
A11	45.53

Number question	Score *Measure Order*
A12	57.19
A13	49.50

The larger the score value of the measure order in the Wright map, the higher the difficulty level. Each number has a different statement. The difference in measure order values indicates that there are differences in answers between one student and another. This difference causes an imbalance in the level of difficulty in each question.

3.2 Discussions

The analysis of statements given to students in the form of a questionnaire provides an analysis related to students' understanding of clean and affordable energy sources. Student response data was obtained from student response questionnaires filled out after the learning process through Google Forms. The response questionnaire was in the form of a Likert scale for 10 statements. All students in all three research classes filled out a response questionnaire. The data from the Google form is then processed using Microsoft Excel to be represented and analyzed. The Likert scale used is 1 to 4. Scale 1 to strongly disagree, scale 2 to disagree, scale 3 to agree, and scale 4 to strongly agree.

Based on the data from the experiments, students tend to know the virtues of clean energy, but in its implementation, students have not gained knowledge about the use of affordable clean energy. This can be seen from the results of the questionnaire analysis, with a total percentage of 87%. Students as a whole in giving responses do not agree. Knowledge of the application of clean and affordable energy requires more intense information transfer than just understanding terms and definitions (Jayachandran et al., 2022). If we look at the overall data on the use of response questionnaires given to students, it can be seen that students' interest in answering questions is actually quite high. This interest arose because it was based on the number of diverse answers from the number of students in the two schools.

There are many reasons to respond to the concerns of different students' understanding and varying levels of implementation in life, one of which is in classroom learning. In learning in class, the physics material taught has not touched on the discussion related to clean and affordable energy (Tanti et al., 2020). When studying physics in class, the material taught often focuses more on basic physics concepts. A little physics study relates energy changes to impact. In fact, with increasing awareness of climate change and the need to transition towards more environmentally friendly energy sources, knowledge about clean energy can broaden students' horizons regarding the application of physics in real-world contexts. In physics learning in two different schools, namely schools with city and district domiciles, there are different responses regarding the view of the use of clean and affordable energy. This can be seen in the following image,

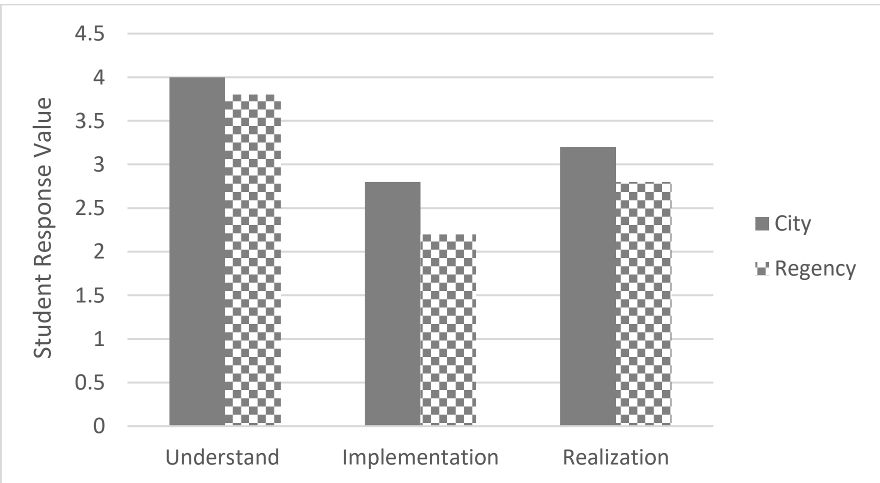

Figure 2. Comparison of Differences in Responses of Students Domiciled in Cities and Regencies

Based on the figure, the domicile of students affects the viewpoint in understanding the use of clean and affordable energy sources. City domicile has a greater understanding than district domicile. This difference in understanding is influenced by differences in the environment and daily behavior that affect the viewpoint of thinking in each region (Wijaya et al., 2022). The environment can influence cognitive abilities in energy matters because external factors, such as air quality, lighting, noise, as well as surrounding physical and social conditions, play an important role in influencing concentration, attention, and thinking ability. That is what happens, as does environmental influence, with more natural energy products being discovered, which will make generations think that studying energy is very important. To spread such an ideology, it is very important that the influence of learning is involved. The main challenge for a teacher in teaching physics material while introducing clean and affordable energy sources tends to be heavier in schools with district domiciles rather than cities due to the high influence of students' understanding (Katoch et al., 2024).

Apart from differences in concepts and understanding caused by the influence of differences in domicile, gender also has an influence on determining decisions. Based on numerical data from the Rasch model, it can be analyzed using a Wright map to find out the level of difficulty of the statements given to students. From the acquisition of numerical data as in Table 4, the largest measure order score is at number 8, which means that of the many statements answered by students, statement number 8 is the most difficult statement to answer from both male and female students. Meanwhile, if analyzed from the results of gender differences, it can be seen as follows,

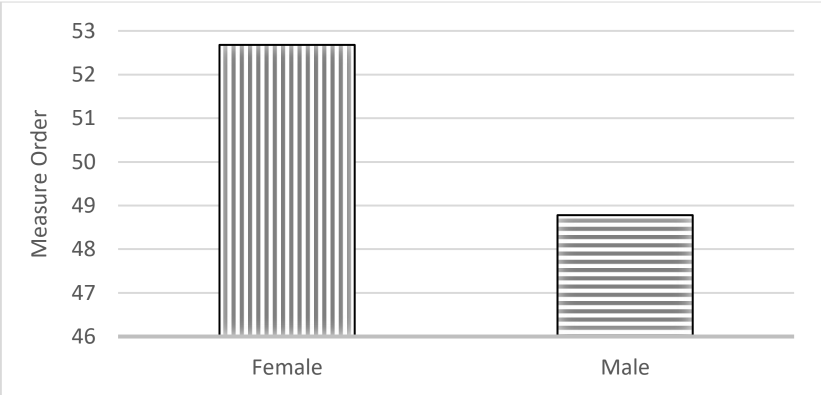

Figure 3. Comparison of the average order value of men and women

The average value of the measure order for men < women tends to be more difficult for women to make decisions or for women to answer the response questionnaire given (Hartatiana, 2020). From all samples in the two different schools, women had difficulty answering statements in the questionnaire, as seen from the more diverse variety of answers. There are differences in understanding based on gender; female students tend to have difficulty understanding energy issues than male students. Female students tend to be more motivated in clean energy and environmental issues, while male students have a stronger technical understanding of sustainability. However, even though they have different levels of difficulty, in general all students have answered the statements from the questionnaire without going through a single thing.

From the overall response of students in responding to the statements given regarding clean and affordable energy, in the development of SDGs point 7 seeks opportunities for access to energy that is affordable, reliable, sustainable, and modern in its use, providing a new perspective for them. Students are more motivated, especially in appreciating point 7 of the 2030 SDGs to implement the use of clean and affordable energy sources. Point 7 of the SDGs will be able to be created with support in maintaining clean energy as an effort to develop more modern and sustainable energy. The role of motivated students is as superior human resources to create renewable energy sources that can later run and survive in development until 2030. This understanding effort can be provided through the application of physics learning, especially in the topic of energy, which can indirectly explain the suitability of the SDGs in the coming years as innovative and sustainable learning. In the future, integrated learning between physics learning in high school and the use of new and affordable energy can be a scientific and educational breakthrough. The hope is not for analysis but for gradual implementation as well.

Conclusion

Based on the research results, an analysis of the understanding and motivation of high school (SMA) students regarding clean and affordable energy sources, in accordance with the 2030 Sustainable Development Goals (SDGs). Students' understanding of clean energy varies, but students tend not to understand its implementation. Clean energy in point 7 of SDGs 2030. From the results of differences in domicile, students in urban areas have better access to information compared to students in rural areas. There are differences in understanding based on gender; female students tend to have difficulty understanding energy issues than male students. Female students tend to be more motivated in clean energy and environmental issues, while male students have a stronger technical understanding of sustainability. These findings are very important in education as a reference profile to increase student awareness and participation in supporting the achievement of SDGs 2030 in sustainable physics learning. The hope is that further physics learning can have an impact on conserving clean and affordable energy sources for sustainable development.

Limitations

In this research, it was carried out in the 2024-2025 learning period, limited to learning physics on clean and affordable energy material. The population in this research sample was limited to one senior high school each in the City and Regency in East Java. Ideally, the sample used should meet the population between the district and city areas. To obtain data with a high level of accuracy, all schools in the Regecy and all schools in the city can be used. Teacher assistance in distributing research instruments is very important. For further research, a larger sample with a further reach can be used to obtain more accurate differences between the understanding abilities of students with different domiciles.

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