

# Utilizing Rasch Model to Analyze A Gender Gap in Students' Scientific Literacy on Energy

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## Abstract

The purpose of this study was to analyze the gap in scientific literacy between male and female students in the subject of energy. This study involves junior high school students which differentiated by gender. The instruments used in this study were the 2006 and 2015 PISA tests, which consisted of nine questions and were analyzed using the Rasch model. The data was analyzed using the Wright map, person measure, item reliability, and DIF. The findings revealed no significant difference between male and female students' scientific literacy, even though male students' percentage results were more significant than female students. Therefore, this study shows no gender gap in students' scientific literacy in energy material. However, students have low literacy, with a logit of -0.51, so physics teachers must create teaching methods to improve students' scientific literacy. This research is useful for providing information on the use of the Rasch analysis model to analyze gender gaps in students' scientific literacy, which has the potential to pave the way for the prevention of bias and the development of more effective strategies in achieving gender equality in science education.

**Keywords:** energy, gender, Rasch model, scientific literacy

## INTRODUCTION

Scientific literacy is an individual's ability to understand science, communicate science, and apply scientific knowledge in solving problems. The competence is needed to be able to highly develop attitudes and sensitivity to oneself and the environment when making decisions based on scientific considerations (Durasu, Sudiatmika, &

Subagia, 2022). Scientific literacy aims to develop students into problem-solvers who can participate as engaged citizens in the real world (Winarni, Hambali, & Purwandari, 2020). People will benefit from scientific literacy by responding critically to critical issues and often occurring occurrences, especially those about science and technology (Novitasari, 2018). Someone with scientific literacy will solve problems by analyzing problems based on

scientific evidence and then drawing scientific conclusions (Adytia & Dwiningsih, 2018). Therefore, students must be facilitated with learning that can apply their knowledge to real life. Students will need literacy skills to be prepared for real-world situations in globalization era (Akbar, 2017). Students proficient in scientific literacy will be able to use what they have learned to effectively handle issues in everyday life (Jufrida, Basuki, Kurniawan, Pangestu, & Fitaloka, 2019).

International student literacy is measured through the Program for International Students Assessment (PISA) test. The PISA evaluation's findings indicate that Indonesian student's levels of scientific literacy are highly concerning. This is evident from students' achievements in scientific literacy from 2000 to 2018, which ranked Indonesia as one of the nations with a low level of scientific competency. In 2018, Indonesia was ranked 71st out of 79 countries, receiving a score of 396, a decrease from the 2015 PISA score of 403 (Agustiani, 2020). The performance of Indonesia in the PISA evaluation from 2000 to 2018 shows that the educational system in Indonesia has not been able to support students' empowerment in scientific literacy (Narut & Supardi, 2019). The lack of scientific literacy in Indonesia illustrates the inability of most students to analyze and apply concepts to solve a problem (Jufrida et al., 2019).

Based on these data, students' scientific literacy needs to be measured from the start to provide an overview to teachers to increase student scientific literacy in the future. This measurement can be done by giving scientific literacy tests to students. To obtain accurate information, students' answers need to be analyzed. The Rasch Model is one method that can be used to evaluate student responses. A psychometric method known as the Rasch model or Rasch analysis offers data about the questions' difficulty level and the respondent's aptitude (Geller, Neumann, Boone, & Fischer, 2014).

The Rasch model is frequently used in various physics research, including developing and evaluating students' alternative conceptions (Aminudin et al., 2019), evaluating pre-service physics teachers' energy literacy (Yusup, Setiawan,

Rustaman, & Kaniawati, 2017), and developing tools to gauge students' conceptual grasp of optical waves (Mešić et al., 2019). The gender gap is also a topic that can be analyzed using the rash model. The gender gap is a circumstance in which there is a sizable achievement gap between male and female students. Many researchers have investigated the role of gender in physics education, such as those conducted by Wilson, Low, Verdon, & Verdon (2016) and Ringo, Samsudin, & Ramalis (2020). The results of the study of Wilson et al. (2016) show that Male students consistently outperform female students in their understanding of physics. However, the research findings done by Ringo, Samsudin, and Ramalis (2020) reveal that even though boys do better on physics tests than girls, there is no significant difference. This demonstrates the need for additional research on gender disparities in physics education, particularly about students' scientific literacy for content directly applicable to daily life.

One of the closely related physical materials in everyday life is energy. Resources that carry out various activities, including fuel, electricity, mechanical energy, and heat, can be defined as energy (Azhar & Satriawan, 2018). Energy is also included in the topic of scientific literacy. This is shown by the energy questions on the 2006 and 2015 PISA tests.

This article analyzes whether there is a gender gap in students' scientific literacy in the field of energy. The results of this examination of the gender gap can be used to determine whether the physics lesson chosen can help students improve their scientific literacy without favoring any gender. The final goal of this paper is to examine the gender gap in scientific literacy between male and female students studying the subject of energy.

## METHOD

This study describes students' scientific literacy using a quantitative descriptive research methodology. Students in class VII ( $n = 57$ ) at a junior high school in Indralaya Regency during the 2022–2023 academic year participated in this study. There were 24 male students and 33 female

students among the participants. According to Sumintono & Widhiarso (2014), the minimum sample suitable for testing in the Rasch model is 30 samples. In research by Ringo et al. (2020) entitled Utilizing Rasch Model to Analyze A Gender Gap in Students' Cognitive Ability on Simple Harmonic Motion, a sample of 36 people was used. In research by Purwanto, Suhandi, Coştu, and Samsudin (2020), a sample of 23 people was used to analyze the gender gap. So, the sample used in this research can represent the analysis using the Rasch Model.

This research consists of three stages: the preparation stage, the implementation stage, and the final stage.

1. Preparation Stage

At this stage, a needs analysis is carried out. Then, indicators of scientific literacy in energy material will be determined.

2. Implemaletation stage

At this stage, the scientific literacy instrumalet was made from the 2006 and 2015 PISA energy-related questions. Then, the instrumalet is distributed to students.

3. Final Stage

At this stage, the data is processed, analyzed, and discussed. Then, conclusions are drawn from the results obtained from the research.

This study used the data collection technique as the test technique. This test technique is a written test that will be distributed to students to measure whether there is a gap between female and male in scientific literacy skills in energy material.

The instrument used in this study was the 2006 and 2015 PISA test instrument on energy, which consisted of 10 questions. The scientific literacy competency indicators in the questions are in Table 1.

This study used the Rasch model to examine the data and identify gender disparities in students' scientific literacy. The steps for processing data are as follows:

- a. The student's raw score that complies with the scoring guidelines per question is inputted into Microsoft Excel

- b. The score is stored in the format "formatted text."
- c. Insert the file into the Ministep application.
- d. Analyzed the data using MINISTEP 4.8.2 to examine the Wright map, person measure, person reliability, item reliability, and differential item function (DIF) data.

**Table 1.** Indicators of scientific literacy competence in questions

Indicator	No. Question
Explain phenomena scientifically	1, 7, 9
Interpret data and evidence scientifically	2a, 2b, 3, 4, 5, 6, 8

Reliability is the determination or consistency of a series of measurement tools. The mark of person reliability and item reliability in Rasch modeling has the criteria presented in Table 2.

**Table 2.** Criteria for person reliability and item reliability (Sumintono & Widhiarso, 2015)

Mark	Criteria
<0.67	Weak
0.67-0.80	Enough
0.81-0.90	Good
0.91-0.94	Very good
>0.94	Special

In Rasch analysis, the person measure shows detailed logit information for everyone. The difficulty level of the questions and students' scientific literacy were determined using Wright's map analysis. Each student received a unique code for data analysis, such as 01M and 25F. The numbered list of students is denoted by the codes 01 and 25. M stands for male, and F for female. Each object is also given a unique code, such as Q1. The number 1 denotes the question's serial number, while the letter Q identifies it as an item.

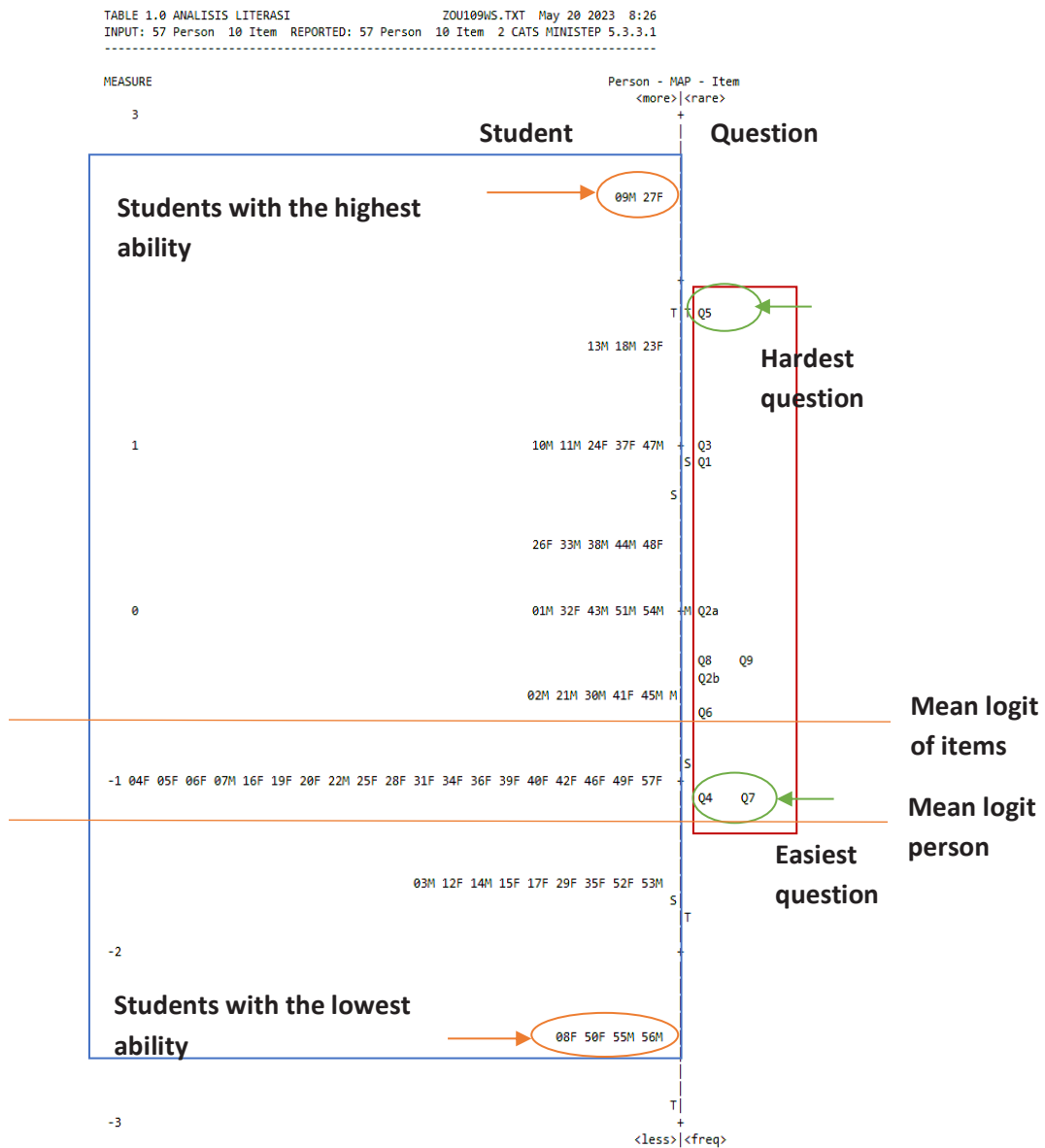
Differential Item Function (DIF) in Rasch Analysis is a method for evaluating whether an item on a test has different characteristics in different groups of respondents (Alavi & Bordbar, 2016). In this case, DIF indicates that an item on the test is biased towards specific groups, which can affect

the overall test results. In the Rasch Analysis, DIF can be identified by comparing respondents' abilities from two groups. In this study, comparisons were made between male and female groups.

### RESULT AND DISCUSSION

The data can be examined using the Rasch model to determine the reliability of the people and

the items. While person reliability indicates the constancy of student answers, item reliability illustrates the reliability quality of the used items. (Ringo et al., 2020). The results of the statistical summary show that the item reliability value for the item about students' scientific literacy is 0.84, and the person reliability value is 0.52. This value indicates that the test items used are reliable, but the student responses generally have poor consistency.



Note: F= Female, M= Male, Q= Question

Figure 1. Wright map

The Wright map uses the same logit scale to show the distribution of difficulty levels and skill levels among respondents (Chan, Ismail, & Sumintono, 2014). A high logit score indicates a high respondent's ability, making questions increasingly difficult for students to answer correctly. The ability distribution of the responses is on the left, while the difficulty distribution of the questions is on the right. These two distributions are opposed (Fajri & Yusmaita, 2021). Based on the predetermined parameters, the Wright map enables the classification of respondent ability and question difficulty distribution. In this study, the distribution of students' scientific literacy in energy material was grouped based on the student's gender.

Wright's map shows that Q5 has the highest logit, indicating the highest difficulty, and Q4 and Q7 have the lowest logit, indicating the lowest difficulty (Figure 1). According to the item size summary, Q5 has a logit of 1.76. Meanwhile, Q4 and Q7 are at -1.06 logit. This question is structured to measure students' scientific literacy abilities. The responders on the left with the highest scores are 09M and 27F, with a logit value 2.52. This value exceeds the logit value that belongs to Q5. These findings show that two male and female students have the highest levels of scientific literacy. At the same time, students with the lowest literacy are 56M, with a logit of -2.46 below the Q4 and Q7 logit values.

According to the findings of the analysis, students can be divided into two groups based on their ability level, namely, those with high ability and those with low ability. Sumintono and Widhiarso (2015) state that the starting point is obvious to the average logit person. The obtained average logit person is -0.51 logit. Thus, the range of student ability categories is shown in Table 3.

Overall, students are in the low category where the average person is worth -0.51 logit, which is lower than the average item, which is 0.00 logit. According to Krisanda & Harjito (2021), the average

measure shows students' ability to work on item items on the instrument; person measure values below the average item measure indicate the item is too difficult for students to work on. The average person measures below 0.0 logit, which reveals that students' scientific literacy skills are below average (Mahtari, Misbah, Hartini, & Suryati, 2019).

**Table 3.** Student ability categories

Category	Logit Value
High	>-0.51
Low	<-0.51

Based on the Wright map in Figure 1, females in the high category are students with code F and above the mean logit person, while female students in the low category are students with code F and are below the mean logit person. Males in the high category are students with code M and above the mean logit person, while male students in the low category are students with code M and below the mean logit person. Categories of student literacy abilities based on gender can be seen in Table 4.

**Table 4.** Students abilities based on gender

Ability	Gender	The Number of Students	Percentage (%)
High	Female	7	21.21
	Male	13	54.17
Low	Female	26	78.79
	Male	11	45.83

Overall, male have higher scientific literacy skills than female, with a presentation of 54.17%, while female is 21.21%, which is in the high category.

More specifically, the scalogram results in Figure 2 show the rankings of the easiest to the most challenging questions and the rankings of the highest to lowest student scores.

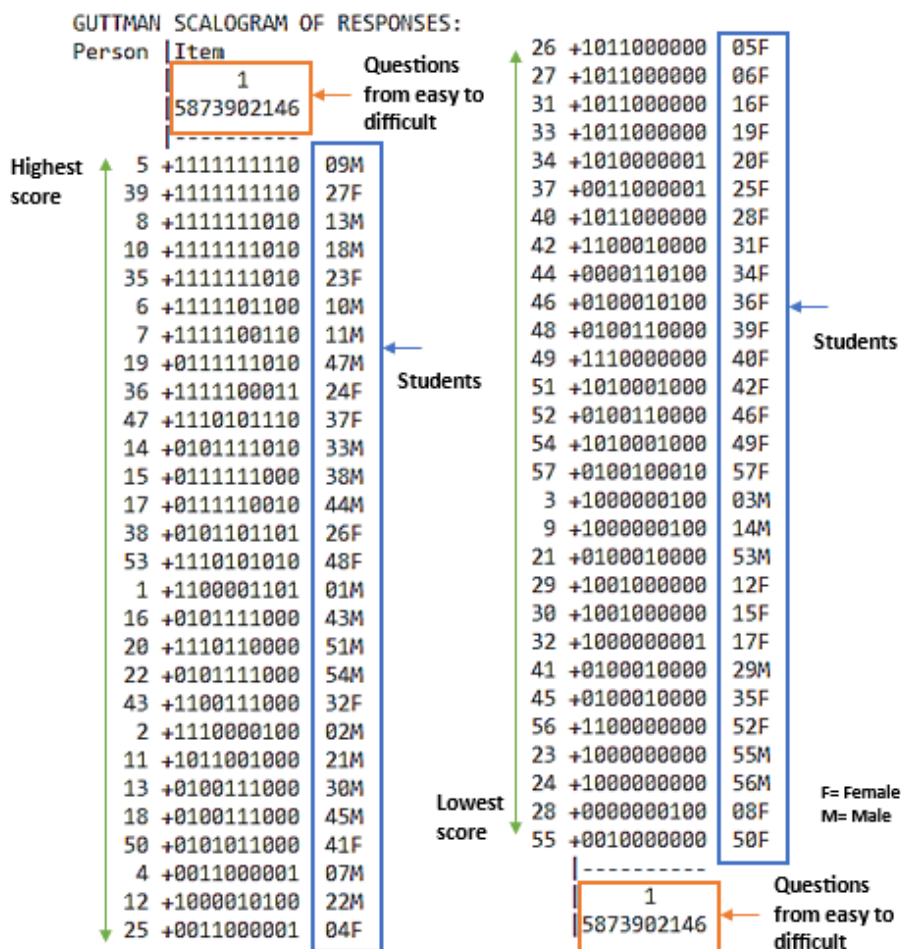


Figure 2. Scalogram

In accordance with Sumintono & Widhiarso (2014), the scalogram has a sequence that can be systematically evaluated from low to high depending on particular criteria. The scalogram demonstrates that it is possible to describe and even anticipate someone's abilities by categorizing questions according to their difficulty and ability (Safitri & Purnamasari, 2020). It can also observe the answer patterns of the male and female students in the scalogram. The order of the questions is displayed in the items section based on the students' responses, going from the easiest to the most difficult. The students with the highest scores are shown in descending order, with lower scores appearing further down the list. Based on

Figure 2, it is also possible to see the responses of male and female students for each indicator, with the indicator explaining phenomena scientifically being found in questions 1 and 9. The number of males determined by paying attention to the L code and the females being determined by the code P, and the indicator Interpret data and evidence scientifically being found in questions 2a to 8 and the number of males being determined by paying attention to the L code and the females being determined by the code C. The comparison of the scientific literacy skills of male and female students is thus displayed in Table 5 based on the indicators of scientific literacy.

**Table 5.** Student abilities based on scientific literacy indicators

Indicator	Gender	Percentage (%)
explain phenomena scientifically	Female	25.76
	Male	45.83
interpret data and evidence scientifically	Female	37.88
	Male	47.92

Examples of PISA 2006 and 2015 instrument test questions used in this research can be seen in Figure 3.

**GREENHOUSE**

*Read the texts and answer the questions that follow.*

**THE GREENHOUSE EFFECT: FACT OR FICTION?**

Living things need energy to survive. The energy that sustains life on the Earth comes from the Sun, which radiates energy into space because it is so hot. A tiny proportion of this energy reaches the Earth.

The Earth's atmosphere acts like a protective blanket over the surface of our planet, preventing the variations in temperature that would exist in an airless world.

Most of the radiated energy coming from the Sun passes through the Earth's atmosphere. The Earth absorbs some of this energy, and some is reflected back from the Earth's surface. Part of this reflected energy is absorbed by the atmosphere.

As a result of this the average temperature above the Earth's surface is higher than it would be if there was no atmosphere. The Earth's atmosphere has the same effect as a greenhouse, hence the term *greenhouse effect*.

The greenhouse effect is said to have become more pronounced during the twentieth century. It is a fact that the average temperature of the Earth's atmosphere has increased. In newspapers and periodicals the increased carbon dioxide emission is often stated as the main source of the temperature rise in the twentieth century.

A student named André becomes interested in the possible relationship between the average temperature of the Earth's atmosphere and the carbon dioxide emission on the Earth. In a library he comes across the following two graphs.

André concludes from these two graphs that it is certain that the increase in the average temperature of the Earth's atmosphere is due to the increase in the carbon dioxide emission.

André persists in his conclusion that the average temperature rise of the Earth's atmosphere is caused by the increase in the carbon dioxide emission. But Jeanne thinks that his conclusion is premature. She says: "Before accepting this conclusion you must be sure that other factors that could influence the greenhouse effect are constant".

Name one of the factors that Jeanne means.

(a)

**FOSSIL FUEL**

Many power plants burn carbon-based fuels and produce carbon dioxide (CO<sub>2</sub>). CO<sub>2</sub> released into the atmosphere has a negative impact on the global climate. Engineers have used various strategies to reduce the amount of CO<sub>2</sub> released into the atmosphere.

One strategy is to burn biofuels as a substitute for fossil fuels. Fossil fuels come from long-dead organisms, while biofuels come from living and recently dead plants.

Another strategy is to trap some of the CO<sub>2</sub> emitted by power plants and store it underground or in the sea. This strategy is called carbon capture and storage.

Referring to those "fossil fuels". Write your answers to the following questions.

Despite the environmental benefits of biofuels, fossil fuels are still widely used. The following table compares the energy and CO<sub>2</sub> released when petroleum and ethanol are burned. Petroleum is a fossil fuel, while ethanol is a biofuel.

Fuel source	Energy released (kJ energy/g fuel)	Carbon dioxide released (mg CO <sub>2</sub> /kJ energy produced by fuel)
Petroleum	43.6	78
Ethanol	27.3	59

According to the table, what are the environmental advantages of using ethanol over petroleum?

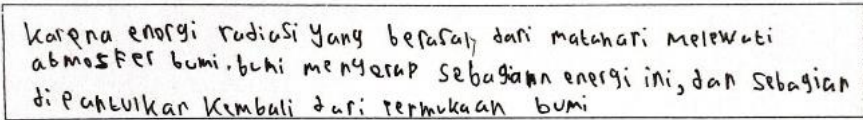
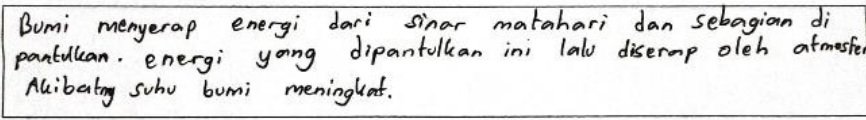
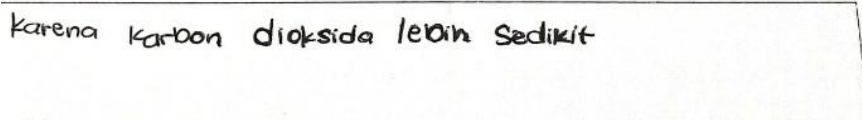
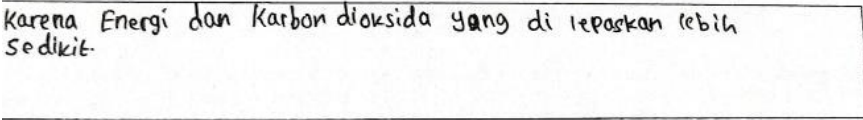
(b)

**Figure 3.** Examples of PISA instrument test questions: (a) questions about explaining phenomena scientifically, (b) questions about interpreting data and evidence scientifically

The PISA question in Figure 3 has two indicator questions: explaining phenomena scientifically and interpreting data and evidence

scientifically. Examples of student answers to questions in Figure 3 can be seen in Table 6.

**Table 6.** Examples of student answers based on questions in Figure 3

Indicator	Answer
Explain phenomena scientifically	<p>harus yakin bahwa faktor lain yang dapat mempengaruhi efek rumah kaca adalah konstan". Sebutkan salah satu faktor yang dimaksud Jeanne.</p>  <p><b>Figure 4.</b> Male students' answers to indicators explain phenomena scientifically</p>
Interpret data and evidence scientifically.	<p>harus yakin bahwa faktor lain yang dapat mempengaruhi efek rumah kaca adalah konstan". Sebutkan salah satu faktor yang dimaksud Jeanne.</p>  <p><b>Figure 5.</b> Female students' answers to indicators explain phenomena scientifically</p> <p>Menurut tabel, apa keuntungan lingkungan menggunakan etanol daripada minyak bumi?</p>  <p><b>Figure 6.</b> Male students' answers to indicators Interpret data and evidence scientifically</p> <p>Menurut tabel, apa keuntungan lingkungan menggunakan etanol daripada minyak bumi?</p>  <p><b>Figure 7.</b> Female students' answers to indicator Interpret data and evidence scientifically</p>

The correct answer to the question with the indicator to explain the phenomena on scientifically is energy/radiation that comes from the Sun. Based on Table 6, male students can directly explain the essence of the answer compared to female students. However, the answers of male and female students refer to the same goal. The correct answer to the question with indicators for interpreting data and scientific evidence is that ethanol produces a small amount of carbon dioxide. Based on Table 6, male students can answer the questions given correctly. Meanwhile, the female student answered correctly but was not quite right because other

answers accompanied it. They both had the same answer: that ethanol produces a small amount of carbon. This shows that male students are better at explaining phenomena scientifically and interpreting data and evidence scientifically than female students. Meanwhile, based on Table 5, if we look at the scientific literacy competency indicators, the highest achievement is in the competency to interpret data and evidence scientifically for both female (37.88%) and male (47.92%) compared to the competency to explain phenomena scientifically for both female (25.76%) and male (45.83%). This is in line with the research



results of Safitri and Mayasari (2018) that the competence to explain phenomena scientifically is lower than the competency to interpret data and evidence, which illustrates that students do not understand the concept of material, so they are not optimal in applying their knowledge based on their surrounding phenomena.

Even though the percentage results obtained by male students were higher than those obtained by female students, the difference was

insignificant. This can be known based on differential item function (DIF) analysis. DIF can reveal the degree of each item's difficulty while also indicating the presence of bias (Ringo et al., 2020). If an item has a DIF probability value above 0.05, then the item is not biased for gender criteria (male and female) (Sumintono & Widhiarso, 2015). Figure 8 shows no gender difference bias in the students' scientific literacy because each item's probability value is more significant than 0.05 (5%).

TABLE 30.4 ANALISIS LITERASI ZOU625WS.TXT May 21 2023 15:37  
 INPUT: 57 Person 10 Item REPORTED: 57 Person 10 Item 2 CATS MINISTEP 5.3.3.1

DIF class/group specification is: DIF=\$S3W1

Person CLASSES	SUMMARY DIF			BETWEEN-CLASS/GROUP			Item Number Name
	CHI-SQUARED	D.F.	PROB.	UNWTD MNSQ	ZSTD		
2	.1606	1	.6886	.1640	-.49		1 Q1
2	1.2951	1	.2551	1.3459	.69		2 Q2a
2	.0251	1	.8742	.0245	-1.03		3 Q2b
2	.0023	1	.9619	.0029	-1.35		4 Q3
2	1.4390	1	.2303	1.5022	.78		5 Q4
2	3.6580	1	.0558	4.0186	1.72		6 Q5
2	1.5122	1	.2188	1.5784	.82		7 Q6
2	.3977	1	.5283	.4082	-.08		8 Q7
2	.8959	1	.3439	.9301	.42		9 Q8
2	.8959	1	.3439	.9301	.42		10 Q9

Figure 8. DIFF on student's scientific literacy

Further analysis of differences in scientific literacy skills based on gender also looks at the items'

difficulty level, which illustrates the results in Figure 9.

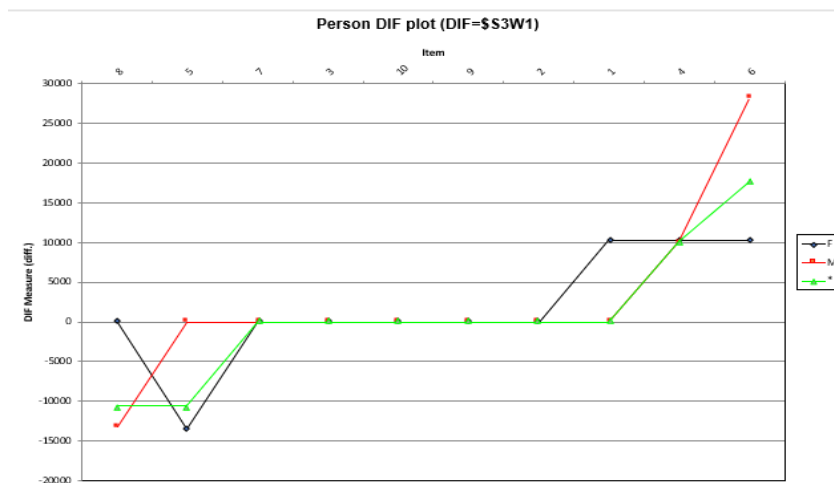


Figure 9. Person DIF plot

Figure 9 shows the average value as a green line, a red line for male students, and a blue line for female students. This demonstrates that male and female students receive different grades. However, this does not provide a significant difference or does not provide an advantage for specific genders. This aligns with the results of Ringo et al. (2020), which reveal that not all questions provide an advantage for a particular gender. In addition, it can also be assumed that male and female students do not outperform each other.

According to this research, there was not a gender gap in scientific literacy of energy materials among students. However, because overall student scientific literacy is still low and overall student ability is below item average (-0.51 logit), these results cannot be the outcome of a successful learning process. Therefore, teachers must provide learning to increase students' scientific literacy and reduce gender gaps. This is because in this study it was found that there is no gender gap in scientific literacy of energy materials among students as indicated by a DIF probability value above 0.05, but students' scientific literacy as a whole is in the low category with an average of -0.51 logit.

## CONCLUSION

This study's results indicate no gender gap in students' literacy in energy material as indicated by a DIF probability value above 0.05. However, this research also informs that students' scientific literacy is low, with an average of -0.51 logit. Based on this, physics teachers must create teaching methods to raise scientific literacy.

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