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Analysis of Students Creative Thinking Skills in Solving Problems on Global Warming Material Using the Rasch Model

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Abstract

This study aims to analyze students' creative thinking skills in solving physics problems related to the topic of global warming using the Rasch Model approach. Creative thinking is an essential component of 21st century skills, encompassing four main indicators: fluency, flexibility, originality, and elaboration. The research utilized a descriptive qualitative design supported by quantitative analysis using the Rasch Model to assess the quality of test items and the distribution of students' abilities. A total of 25 eleventh-grade students from a public high school in Lebak Regency, Banten, participated in the study. The sample was selected using cluster random sampling. The instrument used consisted of eight open-ended essay questions that were validated by experts and tested for internal consistency, yielding a high reliability coefficient (α = 0.86). The results indicated a wide variation in students' creative thinking skills. Most students fell into the high (28%) and moderate (24%) categories. The fluency aspect showed the highest achievement level (72%), reflecting students' ability to generate ideas, while flexibility (63.5%) showed the lowest, suggesting challenges in producing ideas from diverse perspectives. Rasch model analysis showed that most test items were categorized as easy and did not sufficiently challenge higher-ability students. Interview data supported these findings, showing that students frequently gave generic responses lacking originality and depth. These results indicate that current physics instruction has not fully fostered students' creative potential. Therefore, it is crucial to implement contextual, open-ended, and real-world problem-solving-oriented learning strategies to better support the development of creative thinking in physics education.

Introduction

Efforts to improve the quality of education are carried out by adapting to the changes and dynamics of the 21st century (Blyznyuk et al., 2025; Nasir et al., 2025). In this era, the world of education is faced with the challenge of shaping a generation that is capable of solving problems, making wise decisions, thinking creatively, communicating ideas effectively, and working both individually and collaboratively (Maysyaroh & Dwikoranto, 2021).

Physics plays a crucial role in supporting the development of various branches of science and technology. Therefore, physics education should not be limited to understanding theoretical concepts alone, but should also be directed toward developing students' 21st century skills. (Hamdi et al., 2023). This is becoming increasingly relevant considering that the progress of a nation in the modern era no longer relies entirely on the availability of natural resources, but rather on the ability of its human resources to create innovation, solve problems creatively, and adapt to changing times (Mahombar et al., 2023; Darmawan, 2025; Aggarwal et al., 2025).

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Thus the integration of 21st century skills in Physics subjects is an important strategy in forming a generation that is resilient, visionary, and ready to face global challenges. (Rohman et al., 2021). To answer this challenge, one of the skills that can be developed is creative thinking skills which are part of 21st century skills, namely 4C: *(Critical Thinking, Creativity, Collaboration, Communication).*

Creative thinking skills are a combination of logical reasoning and divergent thinking that is based on intuition, but still refers to existing data or information, thus allowing various alternative solutions to emerge for a problem (Agustini et al., 2022; et al., 2025; Noviani et al., 2025). Creative thinking skills are also skills for expressing ideas or solving problems in learning that are different from others, as well as generating new ideas that have never existed before (Kassi et al., 2021). Creative thinking is a person's skill in analyzing new information and combining unique ideas or concepts to solve a problem (Qomariyah & Subekti, 2021).

According to Luthfia (2024), there are four main aspects in assessing creativity, namely: *fluency* (fluency in generating ideas), *flexibility* (ability to create ideas from various categories), *originality* (ability to generate unique ideas), and *elaboration* (ability to develop details of ideas). These four indicators are now references in many educational studies as a benchmark for students' creative thinking, including in the context of science learning such as physics. Developing these skills is important to help students become innovative and adaptive problem solvers in facing the challenges of the 21st century (Adeoye & Jimoh, 2023).

The results of the Programme for International Student Assessment (PISA) 2022 show that Indonesia's PISA score in 2022 is lower than in 2018 (OECD, 2023). According to the results of the 2022 PISA issued by the Organization for Economic Cooperation and Development (OECD), Indonesia has experienced a change in its PISA ranking, but not all of these changes are positive. Although Indonesia has increased its ranking, the average score obtained by students has actually decreased (Sulisworo, 2026).

This decrease shows that although there has been an improvement in the relative ranking compared to other countries, in absolute terms, the mathematics ability of Indonesian students has actually decreased (Thien et al., 2015; Sridiasih et al., 2025). This condition requires special attention considering that physics is a scientific discipline that has an important role in developing creative thinking skills (Sujarwanto & Ridwan, 2021). In the context of physics learning, teachers have a responsibility to design a learning process that is not only interesting and enjoyable, but also able to stimulate students' creativity (Rif'at et al., 2020; Radjak, 2025).

Based on the results of initial observations conducted on one of the physics teachers at a public high school in Lebak Regency, Banten, information was obtained that students' creative thinking skills in solving physics problems were still relatively low. Takase et al. (2019) said that, this condition is influenced by several factors, including low student interest in learning, learning methods that tend to be monotonous, and limited laboratory practical facilities that do not support optimal learning (Huda & Ni'mah, 2025; Falentino et al., 2025).

This condition indicates the need for changes in the approach to learning physics in schools. Physics learning should be developed through an innovative, open, and real-life context-based approach, in order to encourage students to think deeply and produce original ideas (Taasoobshirazi & Carr, 2008). Therefore, this study aims to analyze students' creative thinking skills in solving physics problems on global warming material using the Rasch Model approach, in order to obtain a comprehensive and in-depth picture of students' ability patterns and the effectiveness of the assessment instruments used (Chen et al., 2025; Hanun et al., 2025).

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Methods

This study uses descriptive qualitative methods and Rasch Model analysis to identify a deeper picture of creative thinking skills in solving global warming material problems as well as the effectiveness of the instruments used (Amiruddin et al., 2023). The researcher used a survey method to collect data through creative thinking skills tests and interviews. The Rasch model was used to assess the quality of the instrument and see how students' abilities were overall. Qualitative analysis describes the pattern of student understanding based on the results of the tests and interviews. The sample in this study consisted of 25 grade 11 Phase F students from a high school in Lebak Regency, Banten who had studied global warming material. Sampling was conducted using the cluster *random sampling method*, namely by selecting groups of students randomly from predetermined schools. The participating students consisted of 11 males and 14 females, with the majority being 17 years old. This sample was selected to ensure that students understood the purpose of the study (Cochrane & Robinson, 2019). The main instrument in this study was a creative thinking skills test consisting of 8 multiple choice essay questions designed to measure CTS indicators, namely *fluency, flexibility, originality, and elaboration* on global warming material. The questions consisted of 2 fluency questions, 2 flexibility questions, 2 elaboration questions, and 2 originality questions. The reliability test of the instrument was carried out using Cronbach's Alpha, and a value of 0.86 was obtained, indicating that the instrument has a very high level of reliability. Data were collected through the implementation of creative thinking skills tests given to students in one meeting. In addition, interviews were also conducted to gain a deeper understanding of students' learning experiences related to creative thinking skills and also global warming material. Before the test was given to students, the test instrument had been tested by an expert validator. The data obtained were then analyzed through a qualitative descriptive approach, which includes the process of grouping data, tabulating, presenting results, and relevant calculations. The analysis also includes calculating the percentage of students' answers to reveal their understanding patterns of creative thinking skills.

Table 1. Categories of Students' Creative Thinking Skills

Interval	Category
86% - 100%	Very High
76% - 85%	High
60% - 75%	Moderate
55% - 59%	Low
< 55%	Very Low

The Rasch analysis process was carried out with the help of WINSTEP software and includes several important aspects. Researchers also use Person Measure to measure student abilities in logit units, thus allowing for comparisons between individuals 9 (Cochrane & Robinson, 2019). Meanwhile, Wright Map or Variable Map is used to visualize the distribution of student abilities and the location of test items on a measurement scale (Uba & Khairani, 2024). Through this approach, we can see the suitability between the level of difficulty of the questions and the students' abilities.

Results and Discussion

The assessment of creative thinking skills is carried out by presenting an instrument in the form of essay questions that have been designed according to the indicators of creative thinking. The scores obtained by each student are then processed into a percentage to describe their skill level. After that, the results are classified into the category of creative thinking skills as shown

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in Table 1. The following is a recapitulation of the data on the results of students' creative thinking skills.

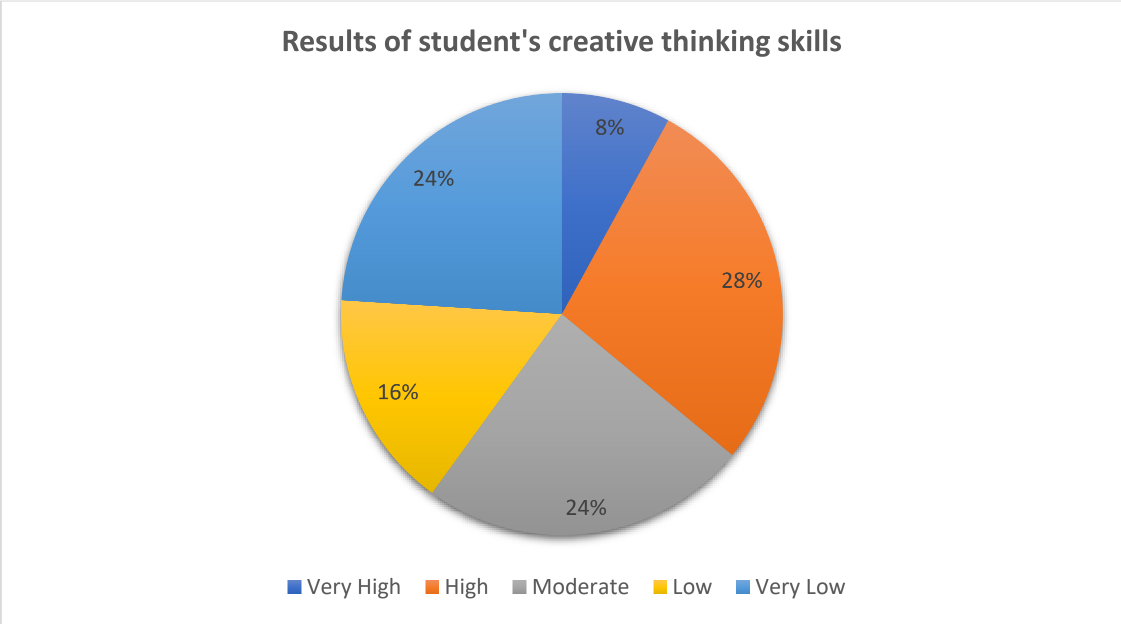

Figure 1. Students' Creative Thinking Skills

Based on the results of the measurement of students' creative thinking skills, it is shown in Figure 1 in the form of a pie chart. Based on the diagram, it is known that most students are in the high category, which is 28% of the total respondents. This shows that a number of students have shown positive developments in creative thinking and are able to meet most of the indicators measured, namely fluency (fluency in producing ideas), flexibility (diversity of ideas), originality (uniqueness of ideas), and elaboration (development of ideas in detail). The moderate and very low categories each cover 24% of students. Students in the moderate category show quite good indicator achievement but are still inconsistent, while those in the very low category show that their creative thinking skills have not developed optimally, especially in the originality and elaboration indicators.

Meanwhile, 16% of students are in the low category, indicating that their creative thinking skills are still limited and tend to only cover basic indicators such as fluency without being supported by flexibility and in-depth idea development. Only 8% of students are in the very high category, indicating that a small number of students have been able to fulfill all indicators of creative thinking skills to the maximum. Overall, this distribution shows that some students have achieved a good level of creative thinking, but there are still significant groups that need strengthening, especially in terms of flexibility and elaboration of ideas. Assessment of creative thinking skills based on Guilford indicators (Meiarti, 2021) shows that some students almost reach the target in the fluency indicator. While for the other three indicators, namely flexibility, originality, and elaboration, not many have reached the target. This shows that students' creative thinking skills are not trained optimally.

Furthermore, the results of the achievement of each creative thinking indicator show that the level of students' creative thinking skills varies in each aspect. Can be seen in Figure 2.

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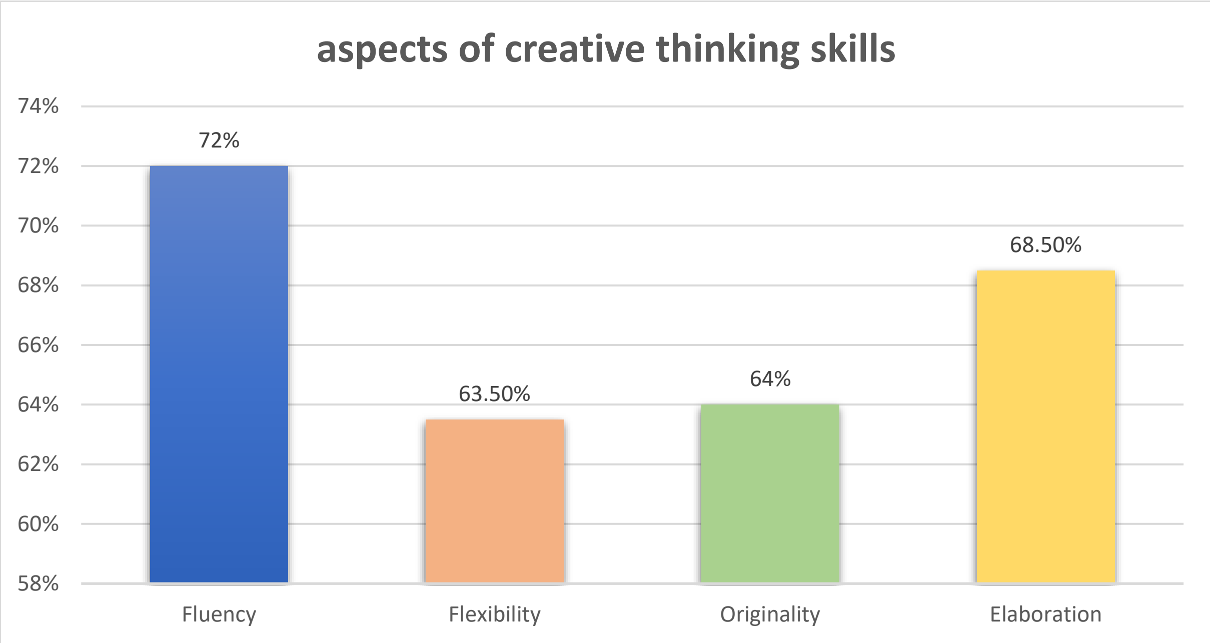

Figure 2. Aspects of Students' Creative Thinking Skills

Figure 2 above shows the average achievement of students in each aspect of creative thinking skills, namely fluency, flexibility, originality, and elaboration. Based on the results of the analysis, the fluency aspect shows the highest percentage of 72%, which indicates that most students are able to produce many ideas or answers fluently in solving the problems given. The elaboration aspect is in second place with a percentage of 68.5%, which shows that students are quite capable of developing ideas in detail and clarifying the ideas they produce. This shows that students are not only able to think quickly, but can also process and expand their ideas quite deeply. Meanwhile, the originality aspect is at 64%, indicating that the level of uniqueness or novelty of students' ideas is moderate. This means that reinforcement is still needed to encourage students to produce more unusual and innovative ideas. The aspect with the lowest value is flexibility, which is 63.5%, which shows that students' ability to generate ideas from diverse perspectives or to think flexibly still needs to be improved.

This ability is important to avoid rigid thinking patterns and encourage more diverse solutions to a problem. According to the criteria in Table 1, this result is included in the moderate category. This information shows that students' understanding of creative thinking skills requires significant strengthening. This instrument has high reliability with a Cronbach's alpha value (KR-20) of 0.86, which indicates very good internal consistency in measuring student abilities (Salsabila, 2023). Personal reliability of 0.87 indicates that there is a fairly wide variation in student abilities. In addition, the reliability of the test items of 0.75 indicates that the instrument is stable in measuring students' creative thinking skills (Eliza et al., 2022). The MNSQ Infit value (0.98) and outfit (1.00) which are in the range of 0.5-1.5 indicate that the student response pattern follows the Rasch model so that the analysis results can be interpreted validly.

This analysis is the basis for conducting a more in-depth evaluation using the Rasch framework, which includes measuring student abilities, analyzing the suitability between data and models, and mapping the relationship between students and questions. This approach strengthens the evaluation's ability to identify and assess creative thinking skills more accurately and meaningfully. Individual measurement using the Rasch Model provides information regarding the position of student abilities relative to the level of difficulty of each question item, which

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is measured in logit units (Planinic et al.,2019). In this study, questions were designed to assess the extent to which students understand the topic of global warming. This can be seen in Figure 3.

Person STATISTICS: MEASURE ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	JMLE MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMEASUR-AL CORR.	PTMEASUR-AL EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Person
14	30	8	4.95	.79	.81	-.14	.77	-.08	.34	.23	75.0	76.1	14
23	28	8	3.99	.62	.74	-.46	.69	-.51	.31	.31	75.0	57.6	23
5	27	8	3.63	.59	1.23	.64	1.21	.59	.31	.33	50.0	53.5	05
7	27	8	3.63	.59	.80	-.33	1.04	.24	-.10	.33	50.0	53.5	07
12	26	8	3.29	.57	.85	-.21	.81	-.32	.52	.36	62.5	56.3	12
16	26	8	3.29	.57	.82	-.29	.93	-.01	-.34	.36	62.5	56.3	16
21	26	8	3.29	.57	1.09	.34	1.03	.21	.75	.36	37.5	56.3	21
2	25	8	2.98	.56	1.63	1.38	1.64	1.38	.03	.37	25.0	57.1	02
4	25	8	2.98	.56	1.29	.75	1.31	.80	.33	.37	25.0	57.1	04
15	24	8	2.67	.55	.89	-.12	.88	-.15	.55	.39	62.5	55.9	15
19	23	8	2.37	.55	1.30	.78	1.34	.86	-.30	.40	62.5	51.3	19
9	22	8	2.06	.56	.98	.10	.97	.08	.32	.40	37.5	51.3	09
17	22	8	2.06	.56	.67	-.72	.68	-.67	.66	.40	37.5	51.3	17
20	21	8	1.75	.57	.70	-.57	.69	-.60	.74	.40	50.0	53.0	20
22	20	8	1.42	.58	.67	-.60	.69	-.54	.26	.40	50.0	54.8	22
11	19	8	1.07	.60	.81	-.21	.72	-.39	.15	.39	50.0	63.0	11
13	19	8	1.07	.60	3.14	2.81	3.09	2.70	.36	.39	37.5	63.0	13
1	18	8	.69	.63	.46	-.98	.51	-.83	.41	.38	87.5	67.6	01
10	18	8	.69	.63	1.02	.23	1.11	.38	.55	.38	62.5	67.6	10
3	17	8	.29	.64	.73	-.27	.75	-.22	.71	.37	75.0	69.5	03
25	16	8	-.12	.64	.48	-.82	.47	-.82	.70	.35	75.0	69.8	25
18	15	8	-.52	.62	1.72	1.19	1.85	1.32	.32	.34	75.0	68.0	18
6	14	8	-.89	.60	.36	-1.35	.34	-1.40	.53	.34	87.5	63.0	06
8	14	8	-.89	.60	.47	-1.01	.48	-.96	.34	.34	87.5	63.0	08
24	14	8	-.89	.60	.88	-.03	.92	.05	.56	.34	62.5	63.0	24
MEAN	21.4	8.0	1.80	.60	.98	.01	1.00	.05			58.5	59.9	
P.SD	4.8	.0	1.66	.05	.55	.88	.55	.87			18.3	6.7	

Figure 3. Measure Person

Figure 3 presents an analysis showing the varying levels of student ability with an average of 1.80 logit and a standard deviation of 1.66 logit. This value indicates that, in general, student ability is slightly above the item difficulty level. There is a fairly wide variation in ability, where some students show high conceptual understanding, while others still have difficulty.

We can also see that the *expected scores* of students vary between 46.3% and 86.1%, with an average of 63.3%, reflecting the consistency of the Rasch model in predicting student performance based on their logit ability. Students with high logits have high expectations of success on the items, while students with low logits indicate a possibility of difficulty in solving most of the problems (Ardianti et al., 2023). This indicates that the Rasch model works optimally in mapping the relationship between individual ability and the probability of answering a question correctly, while supporting the accuracy of the instrument in distinguishing the level of student understanding. Then the analysis of the suitability of student responses to the Rasch model can be seen in Figure 4.

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Person STATISTICS: MEASURE ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	JMLE MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMEASUR-AL CORR.	PTMEASUR-AL EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Person
14	30	8	4.95	.79	.81	-.14	.77	-.08	.34	.23	75.0	76.1	14
23	28	8	3.99	.62	.74	-.46	.69	-.51	.31	.31	75.0	57.6	23
5	27	8	3.63	.59	1.23	.64	1.21	.59	.31	.33	50.0	53.5	05
7	27	8	3.63	.59	.80	-.33	1.04	.24	-.10	.33	50.0	53.5	07
12	26	8	3.29	.57	.85	-.21	.81	-.32	.52	.36	62.5	56.3	12
16	26	8	3.29	.57	.82	-.29	.93	-.01	-.34	.36	62.5	56.3	16
21	26	8	3.29	.57	1.09	.34	1.03	.21	.75	.36	37.5	56.3	21
2	25	8	2.98	.56	1.63	1.38	1.64	1.38	.03	.37	25.0	57.1	02
4	25	8	2.98	.56	1.29	.75	1.31	.80	.33	.37	25.0	57.1	04
15	24	8	2.67	.55	.89	-.12	.88	-.15	.55	.39	62.5	55.9	15
19	23	8	2.37	.55	1.30	.78	1.34	.86	-.30	.40	62.5	51.3	19
9	22	8	2.06	.56	.98	.10	.97	.08	.32	.40	37.5	51.3	09
17	22	8	2.06	.56	.67	-.72	.68	-.67	.66	.40	37.5	51.3	17
20	21	8	1.75	.57	.70	-.57	.69	-.60	.74	.40	50.0	53.0	20
22	20	8	1.42	.58	.67	-.60	.69	-.54	.26	.40	50.0	54.8	22
11	19	8	1.07	.60	.81	-.21	.72	-.39	.15	.39	50.0	63.0	11
13	19	8	1.07	.60	3.14	2.81	3.09	2.70	.36	.39	37.5	63.0	13
1	18	8	.69	.63	.46	-.98	.51	-.83	.41	.38	87.5	67.6	01
10	18	8	.69	.63	1.02	.23	1.11	.38	.55	.38	62.5	67.6	10
3	17	8	.29	.64	.73	-.27	.75	-.22	.71	.37	75.0	69.5	03
25	16	8	-.12	.64	.48	-.82	.47	-.82	.70	.35	75.0	69.8	25
18	15	8	-.52	.62	1.72	1.19	1.85	1.32	.32	.34	75.0	68.0	18
6	14	8	-.89	.60	.36	-1.35	.34	-1.40	.53	.34	87.5	63.0	06
8	14	8	-.89	.60	.47	-1.01	.48	-.96	.34	.34	87.5	63.0	08
24	14	8	-.89	.60	.88	-.03	.92	.05	.56	.34	62.5	63.0	24
MEAN	21.4	8.0	1.80	.60	.98	.01	1.00	.05			58.5	59.9	
P.SD	4.8	.0	1.66	.05	.55	.88	.55	.87			18.3	6.7	

Figure 4. Person Suitability Analysis

Based on the results in Figure 4, the analysis of the suitability of student responses to the Rasch model is evaluated through the Outfit Mean Square (MNSQ) value. Outfit MNSQ reflects the consistency of student responses to test items, especially on items that are far from their ability level (misfit or unexpected responses). The ideal Outfit MNSQ value is in the range of 0.5 to 1.5, which indicates that student responses are in accordance with model expectations. Based on the results displayed, the Outfit MNSQ values of students ranged from 0.34 to 3.09, with an average of 1.00 and a standard deviation of 0.55. The majority of participants had Outfit values within acceptable limits, indicating that their responses to the test items were relatively consistent. However, there were several participants such as entry number 2 (outfit MNSQ = 1.64), number 13 (outfit MNSQ = 3.09), and number 18 (outfit MNSQ = 1.85) who exceeded the ideal limit. This value indicates the possibility of inconsistency in answering the questions. In contrast, students at entry number 6 (outfit MNSQ = 0.34) and number 8 (outfit MNSQ = 0.48) indicated a very high level of response consistency.

Although this can reflect good mastery of the material, values that are too low can also indicate that the questions are too easy, or that participants answer based on memorization without a creative thinking process (Abdullah et al., 2022). Therefore, it is necessary to conduct a study on the level of item difficulty and the possibility of overly mechanical answer patterns. Wright Map or Person-Item Map presents the distribution of student abilities (on the left side) and the difficulty level of test items (on the right side) on the same logit scale. On this map, the vertical

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axis shows the level of student ability (person size) from the highest at the top to the lowest at the bottom. This allows us to directly compare how well the items cover the range of participants' abilities. This can be seen in Figure 5.

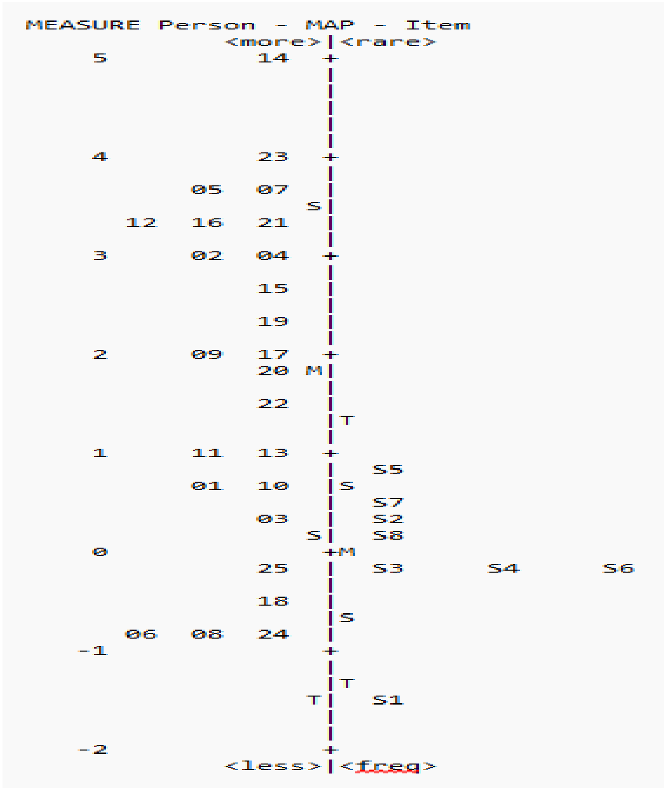

Figure 5. Wright Map Person-Item

Person-item mapping using Wright Map shows the distribution of student abilities and the level of difficulty of questions on the same logit scale. From the student side, abilities are spread between -2 to 5 logits, with an average of 2 logits, indicating that most students have above average abilities. On the other hand, the questions tested are spread from logit -1 to 1, with the average item difficulty at logit 0. This indicates that the questions used in the instrument tend to be in the easy to moderate category, and have not reached a high level of difficulty. For example, questions number 3, 4, and 6 are around logit 0 (moderate category), while numbers 5, 7, 2, and 8 are below logit 1 (easy category). There are no questions that appear at logit above 1. The imbalance between the distribution of high student abilities and the distribution of low question difficulties indicates that the instrument is not yet fully optimal in distinguishing the level of student ability, especially at the upper level. This has an impact on the limitations of the instrument in measuring creative thinking skills.

The assessment of creative thinking skills was also conducted through in-depth interviews with students showing that students' creative thinking skills in understanding and responding to global warming issues are still relatively low. Based on the four main indicators of creative thinking, namely *fluency, flexibility, originality, and elaboration*, it was found that most students had not shown adequate mastery. In terms of flexibility, students tend to stick to one approach in solving problems. One respondent said, "I usually just use the method taught by the teacher, I don't think of other ways" (Student 4). This quote shows limitations in thinking across perspectives or strategies, which is an important indicator of creative thinking skills. In terms of originality, the majority of students tend to provide general answers and do not reflect unique ideas. This is reflected in the statement of one student: "I just answer according to the

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examples in the book, afraid that if I am different it will be considered wrong" (Student 3). This quote shows a tendency towards convergent thinking, which inhibits the emergence of new ideas that have not been presented before.

Some students also seemed reluctant to explore ideas outside the context of what has been taught. One student said, "If my answer is different from my friends, it won't connect, I'd rather just follow the general one" (Student 2). This attitude indicates social pressure and a preference for uniformity, which negatively impacts the development of originality in thinking. The lack of encouragement to express creative ideas can also be caused by minimal learning experience in dealing with open-ended tasks. As one student admitted, "I've never been asked to create my own unique answer, usually I just follow the examples" (Student 2). This underscores the importance of providing space in learning to stimulate the expression of unique and personal ideas. Furthermore, in the elaboration aspect, the lack of elaboration is evident in students' tendency to provide concise answers without in-depth explanations. One student stated, "I just keep my answers short so I can finish quickly" (Student 1), indicating a learning motivation that is pragmatic and less oriented towards deep thinking processes.

This finding shows that the learning that has been going on has not fully encouraged students to develop their creative thinking potential optimally. The low level of creative thinking skills can also be caused by a learning approach that still focuses on memorizing facts and has not provided space for exploring ideas, open discussions, or solving real problems (Syahrudin & Ermalis, 2022). So, to improve students' creative thinking skills, it is important for the learning process to provide more space for exploring ideas and solving problems that are relevant to real life, encouraging students to produce more than one answer to a question, and providing them with the opportunity to put forward ideas that are unusual or different from common practice (Wardani et al., 2021).

One strategic step that can be taken is to provide open questions that challenge thinking and do not have one right answer. This will help students get used to thinking divergently (Wulandari et al., 2023) consider different possibilities, and develop unique solutions. It is also important to create a safe learning environment and respect every idea that comes up, without immediately judging whether it is right or wrong (Holley & Steiner, 2005). When students feel valued, they tend to be more confident in expressing their ideas, even if they are not perfect. A positive attitude towards diversity of thought is key to fostering originality. In addition, providing constructive feedback on every idea students present will help them refine their ideas (Schut et al., 2022). Feedback that not only assesses the final result, but also the thinking process, can improve elaboration skills and encourage students to think more deeply. Unlike previous studies that only focused on cognitive achievement in assessment, this study integrates discrepancy analysis using the Rasch model and qualitative interview data. Thus allowing for a deeper exploration of students' creative thinking skills.

Conclusion

The results of the study indicate that students' creative thinking skills in solving problems on global warming material have not yet developed optimally. Most students showed good achievements in the fluency aspect, but the ability in the flexibility and originality aspects was still relatively low. Analysis using the Rasch Model showed that the instrument used had high validity and reliability, although the distribution of the level of difficulty of the questions was not fully balanced with the students' abilities. The results of in-depth interviews strengthen the quantitative findings, where students tend to provide conventional, less varied, and not yet in-depth answers. This condition reflects that the ongoing learning does not fully support the development of creative thinking skills. The implications of this finding indicate the need for

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a physics learning design that emphasizes the exploration of ideas, divergent thinking, and solving real problems to optimally stimulate students' creative thinking skills. Further research is recommended to involve a larger number of participants and other physics material contexts to test the consistency of the results. In addition, experiments on the direct application of innovative learning models (for example, project-based or collaborative STEM models) can also be conducted to see the effect of direct interventions on improving students' creative thinking skills.

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