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Research Artikel

**PROFILE OF STUDENTS' CREATIVE THINKING IN INTEGRATED  
PHYSICS LEARNING IN ENVIRONMENTAL EDUCATION**

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**Abstract**

*The ability to think creatively in physics learning is needed to help students develop creativity in finding solutions to problem-solving, especially those related to environmental education. This study aims to determine the creative thinking profile of 34 senior high school students in Jombang on global warming in learning that integrates environmental issues. The research was conducted using creative thinking ability test questions on global warming material, which were then analyzed descriptively and quantitatively. The research results show that students have scored in the Enough category on four indicators: fluency, flexibility, originality, and elaboration. The research concludes that further research is needed to improve students' creative thinking abilities at the senior high school level, especially on physics material that is related to the environment, including global warming.*

**Keywords:** *Creative Thinking; Global Warming; Physics Learning, Environmental Education;*

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## INTRODUCTION

Learning that can explain phenomena and natural phenomena globally is Physics. Physics is an important subject that can be observed in everyday life (Sari et al., 2018). Physics is a branch of science that exists at the high school level. Physics learning aims to make it easier for students to explain symptoms and phenomena in their surroundings (Septaria et al., 2019). The importance of learning physics for students is because physics is part of human daily life, such as events or phenomena that occur (Guterres et al., 2018). Physics learning aims to foster scientific attitudes and skills and the ability to think using physics concepts in analyzing phenomena (Yuliani, 2017). Physics learning provides an opportunity for students to develop meaningful learning, and students are active in learning, so physics learning activities are more emphasized on providing direct experience to students. Learners can develop knowledge and skills through learning activities.

Environmental problems are often mentioned in various countries as a threat to the world. Environmental problems can cause global warming (Febiyanti et al., 2020). Global warming is a phenomenon, the process of increasing the average temperature of the atmosphere, sea, and land layers on Earth caused by an increase in the concentration of greenhouse gases (Haryanti et al., 2022; Leu, 2021; Parinduri et al., 2018). Global warming is marked by increased temperatures that are getting hotter, weather conditions that are often erratic, the emergence of various diseases, and damage to ecosystems (Herlina & Prasetyorini, 2020; Herpita & Suranto, 2021). Global warming occurs due to the capture of solar or infrared wave radiation emitted to the Earth due to greenhouse gases (Mulyani, 2021). Greenhouse gases released into the atmosphere occur as a result of human activities. An increase in the concentration of greenhouse gases can result in climate change. Climate change is a condition of changing weather patterns for a long time and occurs globally (Leontinus, et al., 2022).

Climate change is a real threat and is detrimental to human life and all living things on Earth (Luthfia et al., 2019). Human activity is causing climate change (Amalia et al., 2022). The

impact of human activities is a decrease in water quality, habitat, forests, health, agricultural land, coastal ecosystems, and irregular weather changes (Mariam, 2018). Therefore, it is necessary to take preventive measures to reduce the impact of climate change. Prevention of the effects of climate change can be done by providing environmental education to students (Radhiyah et al., 2022). Integrating environmental education into learning is a learning process developed for students to gain learning experience with the surrounding environment, which allows students to actively participate to become creative, innovative, and independent individuals in dealing with environmental problems (Lestari et al., 2021).

Environmental problems require innovative solutions to solve the challenges they face. These problems can be a trigger to bring up profiles of students' creative ideas in solving problems by research from (Cheng 2019), which states that the ability to think creatively can be a provision for students in finding solutions to environmental issues. The ability to think creatively is the ability to convey many ideas and ideas when given problems and solve problems in various forms creatively (Maysyaroh, 2021). The development of student creativity stems from their high curiosity about the natural phenomena around them (Wulandari et al., 2021). Creativity is emphasized in creative individuals, processes, products, and environments. The learning objectives in this study are focused on creative personality, with a creative process and environment as supporting objectives (Tayuda and Siswanto, 2020).

Student creativity needs to be trained during the learning process in class because it can stimulate students to think divergently so they can actively carry out beneficial activities, especially for the environment (Halek et al. 2021; Cheng 2019). Various learning studies have been conducted to determine effective strategies for increasing student creativity (Amelia et al., 2021). However, it has yet to be found that it has been implemented in learning based on environmental education. Therefore, this research was conducted to determine the profile of students' creative thinking abilities, especially those related to

physics learning, based on the surrounding environment.

**METHOD**

This study aims to describe the profile of students' creative thinking abilities in integrated environmental education on global warming material. This study uses a quantitative descriptive research technique (Rapika et al., 2018) to describe the situation according to the facts. The stages of the research carried out are followed in Figure 1.

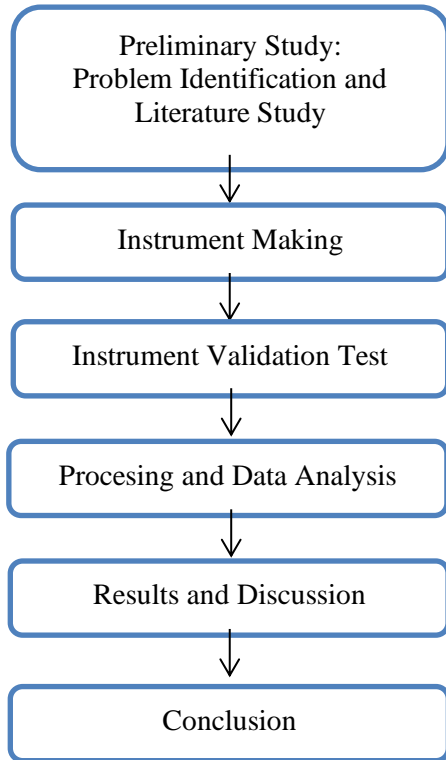



Figure 1. The flow of the research procedure

The research begins with stage 1, a preliminary study where researchers seek to identify problems in learning physics at school and conduct a literature review explicitly focusing on students' creative thinking abilities. They are followed by stage 2, instrument making, compiling creative thinking ability test questions, and response questionnaires to school physics learning. Stage 3, the validation of test questions, is carried out through FGDs by inviting experts in the field of learning to review the instrument qualitatively. Stage 4, processing and data analysis. The data in this study were obtained by administering essay questions that were adjusted to indicators of creative thinking. The questions consist of 10 questions with 2 to 3 questions on each indicator.

The following questions retrieve students' initial data on creative thinking indicators.

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Table 1. Questions with indicators of creative thinking skills

	<b>Indicators of Creative Thinking</b>	<b>Question Item</b>
1.	Fluency	Based on this information, analyze the relationship between congestion and global warming.
2.		Analyze the effects of climate change that can harm farmers in Indonesia as shown in the picture. 
3.	Flexibility	Based on these statements, analyze the effect of changes in global warming on human health.
4.		Give a conclusion from the graphic images and the statement.
5.		Based on the graphic image, analyze the rainfall pattern on climate change.
6.	Originality	Based on the graph, analyze the relationship of carbon dioxide with increasing temperature.
7.		After knowing about the greenhouse effect, do you think that greenhouse gases are still useful for the survival of all living beings on earth?
8.	Elaboration	Based on this problem, as a student, try to find the best way to deal with global warming.
9.		Based on the data above, analyze the relationship between the amount of CO <sub>2</sub>

10	and the temperature in each number in the data. Analyze the effect of the greenhouse effect and carbon emissions due to human activities appropriately on natural events.
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The study was conducted on 34 high school grade XI students in Jombang Regency, consisting of 8 male and 26 female students. The research instrument used in this study was a written test. Written tests determine student learning outcomes in the cognitive domain (Amir et al., 2020). There are ten student essay test questions to estimate creative thinking skills regarding global warming material equipped with indicators of creative thinking ability. Students work on test questions at a predetermined time, then the results of their work are assessed based on the assessment rubric that has been made. The final grade of the student is calculated using the following equation.

$$Grade = \frac{item\ score}{maximal\ score} \times 100$$

Adapted from (Rapika et al. 2018)

The percentage results of the data are then categorized based on the category of creative thinking skills, to determine the level of creative thinking competence.

Table 2. Creative Thinking Category

Range Total Score %	Creative Thinking Category
76-100	Very Good
51-75	Good
26 -50	Enough
0-25	Not Good

Adapted (Leontinus, et al., 2022).

The last is discussion and drawing conclusions based on the results of data analysis. The data obtained and categorized are then discussed qualitatively and quantitatively.

## RESULTS AND DISCUSSION

The research began with conducting *Stage 1, Preliminary Study*, namely identifying learning problems experienced by students, especially in SMA Jombang. Supported by a literature review, it

was found that the problems to be examined were related to students' creative thinking skills. Following *Stage 2, Instrument Making*, this research was conducted to determine students' creative thinking skills with examiners using a written test tool consisting of 10 essay test questions that correspond to 4 indicators of creative thinking, including fluency, flexibility, originality, and elaboration. These four indicators are tools for measuring creative thinking in general (Rasnowati et al., 2019). Students are expected to be able to interpret data, analyze questions, identify phenomena in everyday life, and make conclusions according to instrument questions.

*Stage 3, Instrument Validation Test*, was carried out by involving three experts in the field of physics learning to examine the test questions in a constructive and content manner. The results of the validation show that the test questions can be used in the initial data collection process for the study.

*Stage 4, Processing and Data Analysis*, based on the research that has been done, the results of student's creative thinking skills are obtained in detail for each category as follows. The test results are then calculated, analyzed, and categorized according to the level of creative thinking ability. The following is a description of students' creative thinking abilities.

Table 3 shows the results of the percentage of students' creative thinking abilities in the test questions about global warming, which represent knowledge about the environment and are related to physics concepts. The four indicators show that students' creative thinking abilities are in the sufficient category ( $\leq 50\%$ ). So, that indicates that the profile of students' creative thinking skills integrated with environmental education in global warming material still needs to be improved so that it becomes good (Tayuda and Siswanto, 2020).

Table 3. The results of the achievement of each indicator of creative thinking

Creative Thinking Indicator	Percentage	Category
<i>Fluency</i>	50%	Enough
<i>Flexibility</i>	47%	Enough
<i>Originality</i>	41%	Enough
<i>Elaboration</i>	35%	Enough

## Fluency

The first indicator is fluent thinking. In this indicator, three sub-indicators are used and focused on analyzing a phenomenon in everyday life. In questions number 1, 2, and 3 in Table 1, the maximum score is the same, namely 10 points. The following is a description of the questions used.

Question Number 1. One of the habits of Indonesians before the Eid holiday is going home; it was reported in 2016 that it was recorded as a backflow that had the worst traffic jams in history and was even called the Black Box and the Black Goat, the meaning of the word Black Box is to find the cause of traffic jams and the Black Goat is the party responsible for the congestion problem. That year, it was estimated that the number of public vehicles was 17.99 million people and private vehicles 2.47 million. Based on this information, analyze the link between congestion and global warming. Student answers can be seen in Figure 2.

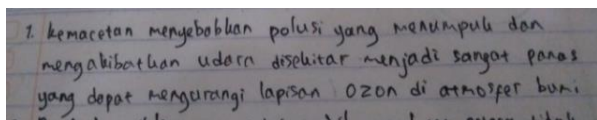


Figure 2. Answers to question number 1

The results of the answers show that students have been able to explain the impact of pollution but have not been able to provide a connection with global warming. This indicates that students cannot provide in-depth and fluent explanations according to the questions.

Question Number 2. A changing climate is marked by changes in world climate patterns that result in erratic weather and disrupt human survival. Analyze the effects of climate change, which can have a negative impact on farmers in Indonesia, as shown in the Figure 3. Student answer can be seen in Figure 4.



Figure 3. Picture of Phenomena Due to Climate Change

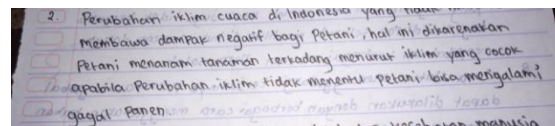


Figure 4. Answers to question number 2

Students have provided answers about the negative impacts of climate change in the agricultural sector but have yet to provide real examples, so students' responses are considered incomplete.

Question Number 3. Global warming not only has a severe impact on the human environment on earth but also health. The World Health Organization (WHO), at its annual meeting in Geneva, said that various emerging infectious diseases were identified as being associated with drastic changes in the environment. Forest destruction, urban expansion, land clearing for agriculture, mining, and ecosystem damage in coastal areas trigger the emergence of old and new pathogens. Various diseases caused by parasites have also increased, especially in areas that often experience drought and floods. Based on this statement, analyze the effect of changes in global warming on human health. Student answers can be seen in Figure 5.

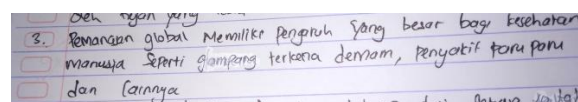


Figure 5. Answers to question Number 3

Students have given examples of diseases related to the impact of global warming on global warming but have not explained the process of influence. This shows the level of students' understanding of global warming knowledge needs to be completed.

In the aspect of fluent thinking, the thing that needs to be considered is the way students explain ideas in writing. Based on the students' answers to questions 1, 2, and 3, it was found that students could state the answers correctly but not fluently/shallowly. Students are only focused on the teacher's instructions, so the explanation needs to be written in depth. The average percentage of answers given by students at the level of student's creative thinking ability in questions 1, 2, and 3 is 50% in the enough category. In questions 1, 2, and

3, many students still need to provide detailed statements and surround them with the material. Students also have yet to be able to give an interpretation of the events around them. This study's results align with research (Devi et al., 2019), which states that most students can still need help understanding an image, story, or problem around them. Supported research (Anike & Handoko, 2018) states that the ability to think creatively, especially in aspects of fluent thinking, aims to produce an innovation of its own with students' answers so that it can show deep understanding answers.

**Flexibility**

The second indicator is flexible thinking. In this indicator, there are three sub-indicators used, namely, to conclude and analyze the graph of the global warming phenomenon. Questions number 4, 5, and 6 have the same maximum score of 10 points. The following is a description of the questions used.

Question Number 4. Simultaneously with the ongoing UN summit on climate change in Copenhagen. The graphic image below shows data from the past, present, and possibly Figure 6.

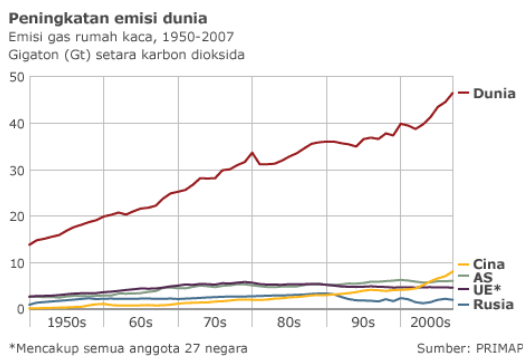


Figure 6. Graph of Increasing Population in 27 Countries

Give a conclusion from the graphic image and the statement. Student answers can be seen in Figure 7.

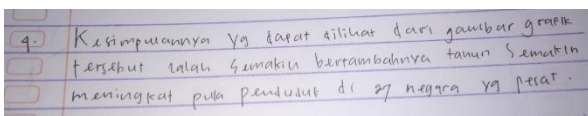


Figure 7. Answers to question number 4

The student's answer to question number 4 was considered inappropriate because it only stated the

results of interpreting the improvement path on the graph. Students have yet to find a relationship between variables that should be the core of conclusions that can be linked to global warming.

Question Number 5. Climate change in Indonesia can be observed from the average rainfall pattern in several regions in Indonesia. The following is a graphical image of the average rainfall in Malang Regency in 2009-2018. Based on the graphical images, analyze the pattern of rainfall on climate change. The graphic image below shows Figure 8.

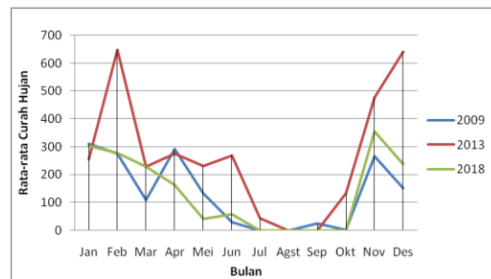


Figure 8. Graph of Rainfall in Malang Regency in 2009-2018

Student answers can be seen in Figure 9.

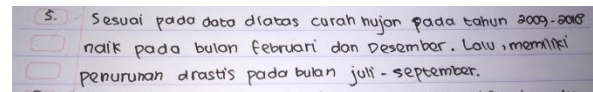


Figure 9. Answers to question number 5

The results of the answers have shown that students can read graphs well. Still, students must provide conclusions relevant to the charts, especially facts showing a relationship between rainfall and climate change.

Question Number 6. The increase in carbon dioxide can affect global warming so that it can cause an increase in temperature in the atmosphere, sea, and the Earth's land. The graphic image below shows figure 10.



Figure 10. Graph of the Relationship between CO<sub>2</sub> Concentration and Temperature

Based on the graphic image, analyze the relationship between carbon dioxide and increasing temperature.

Student answers can be seen in Figure 11.

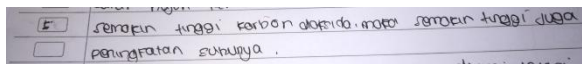


Figure 11. The student answers in question number 6

Student answers to question number 6 already show the relationship between variables on the graph. However, students need to be more flexible in giving answers. This means that the students have yet to be able to state the reasons so that it can be concluded that the higher the amount of CO<sub>2</sub>, the higher the temperature will be.

The average answer given by students in the percentage level of creative thinking ability of students in questions number 4, 5, and 6 is 47% categorized (enough). The average answer given by students is that students have yet to be able to provide conclusions from graphs about the phenomena around them and relate them to global warming and analyze an existing problem correctly. Students make mistakes because there is no interest in these problems; besides that, students need to be used to working on questions with images or graphic motifs. The results of this study agree with the research (Ayu et al., 2020) which states that many students still have the same perception of the questions and answers they give and need help to conclude the information obtained from presenting pictures or graphics. It is supported by research (Yuliani, 2017) which states that the ability to think flexibly means that students must be able to provide various interpretations of an image.

### Originality

The third indicator is original thinking. In this indicator, two sub-indicators are used; students can provide original ideas or opinions that are rarely used by many people and can provide innovative ideas. Question number 7 and 8 have the same maximum score of 10 points. The following is a description of the questions used.

Question Number 7. One of the leading causes of global warming is the greenhouse effect, which is formed due to the heat generated by

sunlight from a collection of gases on the Earth's surface that are trapped in the Earth's atmosphere. These events impact the Earth's temperature, which causes various kinds of problems such as crop failure, melting of glaciers (ice blocks), depletion of the ozone layer, and others. After learning about the greenhouse effect, do you think greenhouse gases are still helpful for the survival of all creatures on Earth?.

Student answers can be seen in Figure 12.

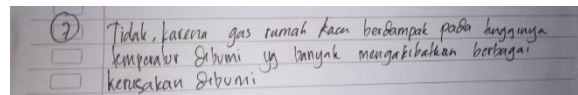


Figure 12. Answers to question number 7

Students' answers conceptually show correct knowledge of warming on Earth. However, students have yet to offer an independent thinking process that can be claimed as new. Therefore, it can be assumed that the student's answer is not original.

Question Number 8. Final changes due to global warming have become a common vocabulary in everyday conversations, especially among scientists. However, this phenomenon still needs to be correctly understood by the public. Hence, misunderstandings or difficulties often occur in distinguishing between climate change and climate variations, sometimes with extreme symptoms. The issue of global warming is heating up, considering the enormous impact it has on life in the world which is suspected to be the cause of world climate change with the various consequences it has caused. Based on these problems, a student tries to find the best way to deal with global warming.

Student answers can be seen in Figure 13.

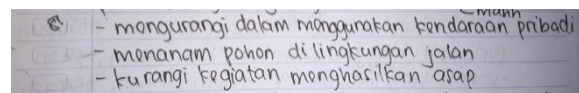


Figure 13. Answers to question number 8

Students can name ways to overcome global warming. However, the students' answers still seemed simple and were commonly done by the community. Students still need to provide solutions that indicate specific activities they may have carried out and had a real impact.

The average percentage of answers given by students at the level of creative thinking ability of students in questions 7 and 8 is 41% categorized (enough). Students have the perception that all problems regarding global warming always have a negative impact on humans and the earth, and cannot yet think that not all problems regarding global warming will have a destructive impact on humans and the earth but have positive and negative impacts if all are following their portions. Students have also been unable to provide new ideas to tackle global warming. This study's results align with the opinion (Elindra, 2017) which states that students must be able to provide many ideas to solve a problem and emphasize the quantity, effectiveness, and variety of answers. This research is in line with research (Monica et al. 2021), which states that original thinking is the ability of students to provide answers that can be combined with existing elements and generate different ideas (Mawarni et al., 2020).

### Elaboration

The fourth indicator is detail. In this indicator, there are two sub-indicators used, namely, to analyze the impact of global warming on activities carried out by humans. Questions 9 and 10 have the same maximum score of 10 points. The following is a description of the questions used.

Question Number 9. The temperature on Earth has recently increased due to global warming; this can be seen from the data below. The following is data on the increase in the temperature of the Earth's surface.

	CO <sub>2</sub> (ppm)	Temperature °C
1	350	0,1-1,0
2	400	1,1-2,0
3	450	2,1-3,0
4	550	3,0-4,0
5	650	5,2-5,8

Based on the data above, analyze the relationship between the amount of CO<sub>2</sub> and the temperature in each number in the data.

Student answers can be seen in Figure 14.

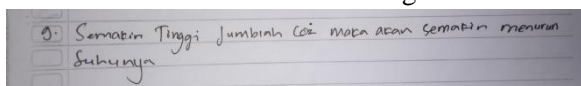


Figure 14. Answers to question number 9

Based on the example of student answers shown in Figure 10, students only mentioned one thing from the results of the table analysis. Therefore, students are said to be not good at thinking in detail because they still need to provide detailed answers to the data shown in the table.

Question Number 10. Human activities such as the habit of frequently shopping, using plastic, using air conditioners, driving, using tissues, and turning on electricity every day are, in fact, the primary keys to the emergence of the greenhouse effect and carbon emissions. Analyze the effect of the greenhouse effect and carbon emissions due to human activities appropriately on natural events. Student answers can be seen in Figure 15.

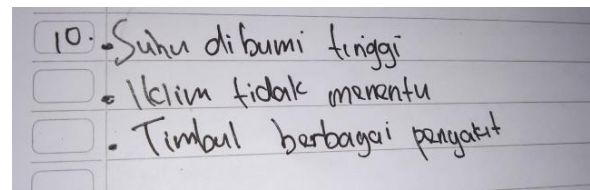


Figure 15. Answers to question number 10

Students have been able to provide examples according to the question but stated. Students should provide complete and detailed answers. This shows that students do not yet have good elaboration aspects and still need to be trained in learning.

The average answer given by students at the percentage level of creative thinking ability of students in questions number 9 and 10 is 35% in the category (enough). Students have been unable to make statements with answers relevant to the information provided and have not been able to link human activities with natural events. This study's results align with research (Ramdani and Apriansyah 2018), which states that the factors that influence students' creative thinking are the ability to understand problems and associate the concept of global warming with events in nature. Supported research (Patmawati et al. 2019) states that students have yet to provide answers that can provide solutions to problems in detail, making it challenging for students to apply them in everyday life. Students need help managing data or information, so they can not reproduce existing ideas.



Based on the discussion that has been done, students have not been able to solve a problem with detailed steps. Students are used to questions that are simple in form without requiring analysis to answer questions, and students are not used to reading graphs and concluding them. It was found that students needed help answering questions due to a lack of understanding of the concept and needed to pay close attention to the question instructions (Ulfa et al. 2018).

## CONCLUSION

Based on the results of the research that has been done, it can be concluded that the creative thinking skills of senior high school students in Jombang for integrated physics learning Environmental education on global warming material is still in the sufficient category, so further research is needed to increase it to the Good until Very Good category. The selection of appropriate innovative learning models is necessary to realize these conditions. The implication of this research is to provide initial evidence regarding students' creative thinking abilities that still need to be improved, especially in dealing with problems related to environmental learning. Further research is required to overcome the low creative thinking skills in high schools in Jombang Regency. Follow-up research is expected to contribute to measuring students' creative thinking abilities

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