Jurnal Ilmiah Pendidikan Fisika
https://ppjp.ulm.ac.id/journals/index.php/jipf/index
e-ISSN: 2549-9963 p-ISSN: 2549-9955
Vol 9 No 2 2025
DOI: https://doi.org/10.20527/jipf.v9i2.15319

Assessing Secondary Students' Attitudes Toward Global Warming

Bayu Eka Putra[1], Andi Suhandi[1,2*], Lina Avianti[1], Mohd Zaidi Bin Amiruddin[2], and Khoirun Nisa'[3]
[1]Physics Education Study Program, Universitas Pendidikan Indonesia, Bandung, Indonesia
[2]Science Education Study Program, Universitas Pendidikan Indonesia, Bandung, Indonesia
[3]Department of Education and Human Potentials Development, National Dong Hwa University, Hualien, Taiwan
*andi_sh@upi.edu

Article Info

Article history:
Received: May 11, 2025
Accepted: June 4, 2025
Published: July 7, 2025

Keywords:
Attitude
Environmental
Global warming
Physics education
Secondary students

This article is licensed under a creative commons attribution-share alike 4.0 international license

© 2025 Jurnal ilmiah Pendidikan Fisika

Abstract

Global warming constitutes a critical topic that must be understood by students, given its far-reaching impacts on the environment, human life, and planetary sustainability. Students' attitudes and responses toward the causes, consequences, and mitigation strategies of global warming play a pivotal role in fostering ecological awareness and promoting environmentally responsible behavior from an early age. This study aims to explore students' attitudes toward global warming in the context of physics education, focusing on their understanding of the issue and its impact on their perspectives on related policies and actions. This study employed a quantitative approach involving 40 tenth-grade students from a senior high school in Indonesia who were studying under the Kurikulum Merdeka. Data were collected using a 4-point Likert scale that measured students' attitudes towards seven main aspects related to global warming. The results showed that the majority of students have a positive attitude towards integrating material on global warming into physics learning and demonstrate awareness of the importance of addressing this issue. However, there are differences of opinion regarding policies on the use of fossil energy and alternative energy. Some students still show a conservative attitude towards fossil energy policies, while others support the policy of using alternative energy that is more environmentally friendly. This study provides important insights into the importance of integrating environmental issues in physics education and its role in shaping a younger generation that is more aware of climate change. The findings are expected to contribute to the development of educational programs that are more relevant and meaningful in raising environmental awareness and sustainability among students.

To cite this article: Putra, B. E., Suhandi, A., Avianti, L., Zaidi Bin Amiruddin, M., & Khoirun Nisa', K. (2025). Assessing secondary students' attitudes toward global warming. *Jurnal Ilmiah Pendidikan Fisika*, *9*(2), 279-297.

INTRODUCTION

Global warming has emerged as a critical global concern due to its profound impacts on both the environment and human life (e.g., Abbass et al., 2022; Sharma et al., 2023). Climate change, rising global temperatures, the melting of polar ice caps, and increasingly frequent extreme weather events serve as clear indicators that the effects of global warming can no longer be overlooked. In this context, public awareness and attitudes toward global

warming play a crucial role, particularly among the younger generation, who will inherit responsibility for the planet's future (Syropoulos & Markowitz, 2024). High school students, as part of this generation, occupy a strategic position in promoting environmental sustainability. However, the extent of their understanding and the strength of their attitudes toward global warming remain uncertain. While many students may be familiar with the term 'global warming,' they may lack a deep understanding of its causes, consequences, and mitigation strategies (Amiruddin et al., 2023; Handayani & Triyanto, 2022). Therefore, investigating students' attitudes toward global warming is an essential step in developing effective educational strategies within science and environmental education.

Although global warming has been widely publicized through various media platforms, a significant gap remains between students' knowledge of the issue and their attitudes toward it. Research has shown that many students possess limited or even inaccurate understandings of the basic concepts related to global warming (e.g., Jarrett & Takacs, 2020; Schauss & Sprenger, 2021). This deficiency is often attributed to several factors, including the insufficient integration of environmental issues into the curriculum, a lack of contextualized teaching approaches, and minimal student involvement in activities that promote environmental conservation. Moreover, in certain contexts, students exhibit apathy or indifference toward global warming, as they perceive its impacts as distant or irrelevant to their daily lives (Bright & Eames, 2022; Herman et al., 2021). This situation is further complicated by the fact that attitudes toward environmental issues are shaped not only by cognitive knowledge but also by social, cultural, and emotional influences (e.g., Barzilai & Chinn, 2020; Eslen-Ziya, 2022; Palmucci & Ferraris, 2023). Consequently, educational approaches that rely solely on knowledge transmission are inadequate. A more comprehensive understanding of the affective dimensions underlying students' attitudes is essential to develop more effective, meaningful, and context-sensitive educational interventions.

Various studies have been conducted to evaluate students' understanding and attitudes towards global warming in different countries. For example, research conducted by Boon (2010) showed that secondary school students in the UK have a good basic understanding of global warming but do not necessarily show pro-environmental attitudes in everyday life. On the other hand, research by Lee et al. (2013) and Lee and Yang (2019) in South Korea, it was revealed that although students have a high level of awareness of the issue, they have difficulty linking it to real action. In Indonesia, similar studies remain relatively limited and have yet to provide a comprehensive overview, especially at the secondary school level. Most local research tends to focus predominantly on cognitive aspects, such as knowledge acquisition, while the affective domain student attitudes, feelings, and motivations has not been explored in depth and often remains limited to a single dimension (e.g., Handayani & Putra, 2019; Pambudi et al., 2024; Perwithosuci et al., 2023; Suratmi et al., 2025). Therefore, there is a pressing need to broaden the scope of research by adopting a more comprehensive approach that not only measures knowledge levels but also holistically investigates students' attitudes toward global warming, including the underlying factors that shape these attitudes.

This study aims to comprehensively examine the attitudes of secondary school students toward the issue of global warming. It also seeks to investigate the relationship between students' backgrounds, their level of knowledge about global warming, and the attitudes they demonstrate. By exploring these dimensions, the study aims to provide a more comprehensive understanding of students' affective dispositions regarding environmental issues. The findings are expected to inform the development of more contextual and meaningful environmental education programs that resonate with students' experiences. Ultimately, this research aspires to contribute to the cultivation of a younger generation

that is more environmentally aware, concerned, and responsible for ensuring the sustainability of the earth. The further research questions (RQ) are presented as follows:

RQ1: How is students' attitude towards the phenomenon of global warming and its handling?
RQ2: How is students' attitude towards the integration of global warming material in physics learning?
RQ3: How is students' attitude towards the assessment of global warming material in physics learning?
RQ4: How are students' attitudes towards student involvement in handling the phenomenon of global warming?
RQ5: How is students' attitude towards policies on the use of fossil fuels as a source of energy?
RQ6: How is students' attitude towards policies on the use of alternative energy sources for electricity supply?
RQ7: How are students' attitudes towards the issue of the impact of global warming?

METHODS

This study employs a quantitative approach, as its primary objective is to identify and describe students' attitudes toward global warming using numerical data (Creswell & Creswell, 2017). This method was deemed appropriate as it involves percentage data that is suitable for descriptive statistical analysis. Data were systematically gathered through a closed-ended attitude scale instrument utilizing a Likert scale to measure students' attitudes regarding climate change. Moreover, the use of a quantitative approach enables the researcher to draw objective conclusions (Rahman et al., 2022).

A total of 40 tenth-grade students (20 females and 20 males), aged approximately 15–16 years, were selected proportionally from official class rosters to ensure balanced gender representation in the data collection. These participants were enrolled in a senior high school implementing the K-12 Independent Learning Curriculum (Kurikulum Merdeka) in Indonesia.

The attitude scale instrument was designed using a 4-point Likert scale to assess students' attitudes toward global warming, with response options ranging from "strongly disagree=1," "disagree=2," "agree=3," and "strongly agree=4" (Alan & Kabasakal, 2020). The use of a 4-point scale aimed to encourage respondents to take a definitive stance by eliminating a neutral option, thereby producing data that more accurately reflects students' attitudinal tendencies. The attitude scale instrument used in this study was developed specifically for this study based on a thorough review of relevant literature and contextual considerations. It is an original instrument designed to accurately capture students' attitudes towards global warming, tailored to the Indonesian secondary school context. The content validity of the attitude scale instrument was confirmed through expert judgment, while its reliability was assessed using Rasch analysis, yielding a reliability coefficient of 0.92 (Muslihin et al., 2022). The instrument consists of 45 statements grouped into seven aspects of attitudes toward global warming (see Table 1). Physics teachers distributed the printed attitude scale instrument to facilitate data collection from students.

Table 1 Attitude toward global warming scale grid

No	Aspects of attitude toward global warming	Number of statements
1	Attitude towards the phenomenon of global warming and its handling	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
2	Attitude towards the integration of global warming material in physics learning	11. 12, 13, 14, 15

No	Aspects of attitude toward global warming	Number of statements
3	Attitude towards the assessment of global warming material in physics learning	16, 17, 18, 19, 20, 21
4	Attitude towards student involvement in handling the phenomenon of global warming	22, 23, 24
5	Attitude towards policies on the use of fossil fuels as a source of energy	25, 26, 27, 28
6	Attitude towards policies on the use of alternative energy sources for the electricity supply	29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40
7	Attitude towards the issue of the impact of global warming	41, 42, 43, 44, 45

After obtaining the raw data from the research instruments, the next step involved processing and analyzing the data. This process began with data input into Microsoft Excel for initial verification purposes, including checking for completeness, consistency, and data identification. Excel was also used to organize the data in a more organized format, making it ready for further analysis. After the initial stage was completed, the data was grouped based on criteria selected by the students. Thus, the sequential use of Excel helped to ensure that the data analysis was systematic, accurate, and scientifically sound (Abbott, 2016). Then the student responses were grouped based on the number of students who chose to agree strongly and who adjusted the positive and negative statements. The categories of student attitudes are presented in Table 2.

Table 2 Interpretation of attitude

Number of Students Who Strongly Agree (+)	Number of Students Who Strongly Disagree (-)	Attitude Category
> 30	> 30	Very Positive
20-30	20-30	Positive
10-19	10-19	Negative
< 10	< 10	Very Negative

(+) = Statement positive; (-) = statement negative

RESULTS AND DISCUSSION

Based on the analysis of the attitude scale instrument on global warming completed by high school students, a general overview was obtained regarding how students perceive the issue of global warming within the context of physics learning. To provide a comprehensive understanding, the results and discussion are presented in a structured manner according to the seven measured aspects of student attitudes.

RQ1: Attitude towards the phenomenon of global warming and its handling

Table 3 shows that students generally have a positive attitude towards the existence of global warming and the importance of addressing the phenomenon. Most students disagree that global warming is just an exaggerated issue (item 1) or that global warming is entirely a natural phenomenon without human intervention (item 2). This is in line with the results of previous research, which states that global warming is influenced by human actions (e.g., Hari et al., 2020; Jehanzaib et al., 2020). The high mean score and low standard deviation indicate a consistent level of student understanding of the reality of global warming. In addition, students showed awareness that global warming is a real phenomenon, evidenced by various conditions on earth (item 3), and needs to be addressed immediately because it is closely related to climate change (item 4). This is proven by previous research conducted by Hansen et al. (2023) and Yilmaz & Can (2020). Support for information dissemination efforts (item 9) as well as recognition of the importance of understanding the contribution

of individual activities to global warming (item 10) indicate that students have a tendency to support collective and educative action in addressing this issue.

Table 3 The first aspect

Attitude towards the phenomenon of global warming and its handling		Strongly Agree		Agree		Disagree		Strongly Disagree	
	Statement	f	%	f	%	f	%	f	%
1	Global warming is just an issue that is blown up so that people experience fear	0	0	0	0	18	45.0	22	55.0
2	Global warming, if it exists at all, is a natural event and has nothing to do with human activity.	0	0	0	0	23	57.5	17	55.0
3	Global warming is real because evidence on Earth has shown that the phenomenon exists	21	52.5	19	47.5	0	0.0	0	55.0
4	Global warming must be addressed because it will lead to climate change	26	65	14	35	0	0.0	0	55.0
5	Climate change, due to global warming, will threaten human survival on Earth.	16	40	24	60	0	0.0	0	55.0
6	The situation on Earth that sometimes feels hot for a certain period of time and feels cold in another interval, shows that global warming does not exist	3	7.5	3	7.5	18	45.0	16	55.0
7	Global warming, if it exists, is nothing to worry about because the increase in Earth's temperature each year is not too large	0	0	4	10	20	50.0	16	55.0
8	Even if it exists, handling global warming is the responsibility of the government.	2	5	5	12.5	19	47.5	14	55.0
9	The existence of global warming and ways to deal with it need to be continuously socialized to all citizens through various modes of information.	30	75	10	25	0	0.0	0	55.0
10	People, including school students, need to know their activities or actions that can accelerate the increase in Earth's temperature	25	62.5	15	37.5	0	0.0	0	55.0

However, ambivalent attitudes were still found in some statements, indicating doubt or a lack of individual responsibility. For example, some students agreed that fluctuating temperature changes indicate no global warming (item 6), indicating a misconception about the difference between weather and climate. These misconceptions have been previously reported in studies (e.g., da Rosa, 2022; Kurup et al., 2021). In addition, the statement that addressing global warming is the responsibility of the government (item 8) indicates a tendency to shift responsibility to external parties. These findings suggest that although general awareness of the global warming issue is quite high, there is still a need to strengthen scientific understanding and foster a stronger sense of personal responsibility among students. Therefore, science education in schools needs to integrate approaches that not only convey information but also form deep conceptual understanding and active attitudes towards environmental issues in a sustainable manner.

Based on the data of students' responses to ten statements about global warming and its handling, the majority of students showed a positive attitude. This can be seen from the high number of students who strongly agree with positive statements, such as "global warming must be addressed" (26 students) and "information about global warming needs to be socialized" (30 students). This reflects students' awareness and concern for environmental issues. On the other hand, negative attitudes still appeared in some negative statements, such as the statement that "global warming is natural and not related to human activities," which was only strongly rejected by 17 students, thus falling into the negative attitude category. In addition, many students have not shown a strong rejection of the view that dealing with global warming is only the responsibility of the government. This suggests that although awareness of the importance of the global warming issue is good, further education is needed to strengthen students' understanding of the role of humans and individual responsibility in addressing this issue.

RQ2: Attitude towards the integration of global warming material in physics learning

Table 4 shows that students generally have a very positive attitude toward integrating material on global warming into physics learning. This can be seen from the responses to the statement that the integration of global warming material into the school curriculum is considered very important (item 11), which obtained a mean value of 3.58, and none of the students disagreed. This has also been discussed in previous research by Mhlongo (2024). Similarly, the statements that knowledge about global warming can increase students' awareness of activities that accelerate global warming (item 14) and the need to provide reading materials related to global warming in schools (item 15) demonstrate that students support an educative and literate approach to this issue. This indicates that students are not only aware of the importance of the issue of global warming, but also consider that physics learning can be a place to improve literacy and care for the environment (Supriatna et al., 2024).

Table 4 The second aspect

Attitude towards the integration of global warming material in physics learning		**Strongly Agree**		**Agree**		**Disagree**		**Strongly Disagree**	
	Statement	f	%	f	%	f	%	f	%
11	Integration of global warming materials into the school curriculum is very important.	23	57.5	17	42.5	0	0.0	0	0.0

Attitude towards the integration of global warming material in physics learning		Strongly Agree		Agree		Disagree		Strongly Disagree	
12	The integration of global warming materials into the school curriculum will only add to the curriculum burden that students must learn.	0	0.0	2	5.0	26	65.0	12	30.0
13	School students should not be ignorant of the global warming phenomenon, whose impacts are very scary.	2	5.0	5	12.5	21	52.5	12	30.0
14	Knowledge of global warming will increase students' awareness of activities that can accelerate global warming.	24	60.0	16	40.0	0	0.0	0	0.0
15	Reading books that discuss global warming and its causes should be made available in schools to enhance students' understanding of the issue.	26	65.0	14	35.0	0	0.0	0	0.0

However, in items 12 and 13, there were some indications that not all students held a fully progressive view. A minority of students agreed that integrating global warming material would only add to the curriculum load (item 12), although the majority disagreed, suggesting a minor concern regarding the learning load. In item 13, although the majority of students disagreed that students should be ignorant of the issue of global warming, the lower mean value (3.08) indicates that perceptions of the urgency and impact of this phenomenon are not fully shared. This finding confirms the need for contextualized and relevant learning strategies that enable students to see the direct connection between physics materials and environmental issues. An interdisciplinary approach that combines physics concepts with global issues such as global warming will support the creation of meaningful learning and shape students' scientific attitudes and social responsibility (e.g., Canlas & Kazakbaeva, 2023; Kumar, 2023).

The results of the analysis show that students have a very positive attitude towards the integration of global warming material in physics learning. A total of 23 students strongly agreed that integrating this topic into the school curriculum is very important, and 26 students strongly agreed that reading books on global warming should be provided at school. In addition, 24 students strongly agreed that knowledge about global warming can increase students' awareness to avoid activities that accelerate global warming. Meanwhile, negative attitudes towards this integration were relatively low. For example, on the statement that this topic will only add to the curriculum burden, 26 students disagreed, indicating that they do not consider this issue an additional burden. Only on the statement that students should not care about the impact of global warming did 21 students disagree, but the number of extreme disagreements did not reach the very positive category. Overall, the data reflect strong support for strengthening climate literacy in schools.

RQ3: Attitude towards the assessment of global warming material in physics learning

Table 5 shows that the majority of students have a positive attitude towards evidence-based and experiential approaches to assessing and learning about global warming. This can be

seen from the students' high agreement with the statement that learning about global warming should be accompanied by evidence of real impacts (item 16) and relevant analogy approaches (item 17). In fact, the majority of students strongly support learning that involves evidentiary practicum activities (item 18). This shows their preference for inquiry-based learning and hands-on experience. Support for the use of visual media that can represent concepts at the microscopic level (item 19) indicates that students recognize the importance of visual aids in explaining abstract concepts, such as the greenhouse effect (Varela et al., 2020). This finding indicates that students tend to favor physics learning approaches that are contextual, concrete, and involve active engagement in understanding global warming issues, which is in line with previous research (Rodríguez-Hernández et al., 2020; Trott, 2020).

Table 5 The third aspect

Attitude towards the assessment of global warming material in physics learning		**Strongly Agree**		**Agree**		**Disagree**		**Strongly Disagree**	
	Statement	f	%	f	%	f	%	f	%
16	Discussion of global warming material in physics learning should be supported by evidence of its impact.	30	75.0	10	25.0	0	0.0	0	0.0
17	To convince students of the existence of the phenomenon of global warming, a relevant analogy approach should be used.	28	70.0	12	30.0	0	0.0	0	0.0
18	The discussion of warming material in physics learning should not only be a story, but needs to be accompanied by practical activities that are evidence-based in nature.	33	82.5	7	17.5	0	0.0	0	0.0
19	To make it easier for students to understand the mechanism of the greenhouse effect that causes global warming, physics teachers need to use a variety of visual media at the level of micro representation.	29	72.5	11	27.5	0	0.0	0	0.0
20	Learning about global warming should be emphasized to construct students' knowledge about global warming.	7	17.5	8	20.0	15	37.5	10	25.0
21	To train creative thinking skills in handling global warming, teachers need to often use the team-based project model in learning about global warming.	17	42.5	12	30.0	6	15.0	5	12.5

On the other hand, not all students were fully aligned with the constructivist approach and project-based learning. Item 20 showed that only some students supported the importance of emphasizing students' knowledge construction in global warming materials, indicating resistance or unfamiliarity with constructivism-based learning approaches. In addition, although more agreed than disagreed, the team project-based learning approach was considered effective in training creative thinking skills to address global warming (item 21). This suggests that some students may not be used to or feel uncomfortable with

learning methods that demand collaboration and high creativity. This finding suggests the need for continuous training and habituation to innovative approaches in physics learning, so that students not only understand the issue of global warming but also develop creative solutions based on a strong scientific understanding.

In general, students showed a very positive attitude towards the evidential, practical, and visual approach to learning about global warming. This is reflected in the dominance of strongly agree responses to statements such as the use of evidence of impact (30 students), the analogy approach (28 students), and evidence-based practicum activities (33 students). In addition, the use of micro-visual media to explain the greenhouse effect also received strong support (29 students). This indicates that students value concrete and experiential learning. However, regarding the emphasis on students' knowledge construction, only seven students strongly agreed, while 25 students showed neutral to negative attitudes, indicating a need to strengthen students' understanding of the importance of an active role in constructing knowledge. Similarly, in the team-based project model, although 17 students strongly agreed, support was not very dominant. Thus, a real and applicable learning approach is preferred by students in understanding the issue of global warming.

RQ4: Attitude towards student involvement in handling the phenomenon of global warming

Table 6 shows that most students showed a positive attitude towards their involvement in addressing global warming issues. In item 22, the majority of students agreed that they can take concrete actions within their capacity as students. This reflects the awareness that although their role is limited, students can still contribute actively through behavior change and participation in environmentally friendly school activities. The discussion is in line with studies on Education for Sustainable Development (ESD) that emphasize the importance of empowering learners to take concrete actions in daily life (e.g., Algurén, 2021; Glavič, 2020). Meanwhile, in item 24, most students also believe that they can play an active role in educating the community about the global warming phenomenon. This support for social engagement indicates that students not only see this issue as the responsibility of the government or certain institutions but also as part of a collective responsibility that they can participate in.

Table 6 The fourth aspect

Attitude towards student involvement in handling the phenomenon of global warming		**Strongly Agree**		**Agree**		**Disagree**		**Strongly Disagree**	
	Statement	f	%	f	%	f	%	f	%
22	Students can take concrete actions to deal with global warming in accordance with their capacity as students.	12	30.0	22	55.0	4	10.0	2	5.0
23	The real action of students in handling global warming is enough to provide an understanding of the existence of the phenomenon of global warming to local residents.	6	15.0	7	17.5	18	45.0	9	22.5

	Attitude towards student involvement in handling the phenomenon of global warming	Strongly Agree		Agree		Disagree		Strongly Disagree	
24	Students can actively participate in socializing the phenomenon of global warming and ways to deal with it to the community according to their capacity.	15	37.5	19	47.5	4	10.0	2	5.0

Additionally, item 23 found that most students doubted the effectiveness of their concrete actions in conveying an understanding of global warming to the community. This doubt may arise due to perceptions of limited age, experience, or access to communication with the wider community (Trott & Weinberg, 2020; Winter et al., 2022). The high standard deviation also indicates considerable variation in attitudes among individuals in this regard. This finding suggests that while students realize the potential of their roles, they still need capacity building, guidance, and institutional support to be more confident and effective in carrying out these roles. Therefore, physics learning that raises the issue of global warming should not only stop at conceptual aspects but also be directed at developing scientific communication skills, community-based projects, and empowering students as agents of environmental change.

In general, the results indicate that students have positive attitudes towards their involvement in addressing global warming. Regarding the statement that students can take concrete actions according to their capacity, 12 students strongly agreed, 22 students agreed, 4 students disagreed, and 2 students strongly disagreed. For the statement regarding students' active participation in socializing the phenomenon and its handling, 15 students strongly agreed and 19 students agreed, while 4 students disagreed and 2 students strongly disagreed. However, on the statement that students' actions are enough to provide understanding to local residents, only 6 students strongly agreed and 7 students agreed, while 18 students disagreed and 9 students strongly disagreed. This shows that although students believe in their ability to act and socialize, they still doubt the real impact of their actions in the community. Further support and encouragement are needed for students to become more confident in their roles.

RQ5: Attitude towards policies on the use of fossil fuels as a source of energy

Table 7 shows that students' attitudes towards policies on the use of fossil fuels, particularly coal, are quite diverse. In item 25, most students disagreed with the promotion of the use of coal as a source of electricity, even though the country is rich in coal. This attitude demonstrates students' awareness of the environmental impact of coal, although a small number still view coal as a cheap energy source that needs to be utilized. When asked directly about the total closure of coal-fired power plants (item 26), the majority of students showed an attitude that was not fully supportive. This indicates a consideration of the national energy needs that still depend on this source. In contrast, in item 27, students favored a phased approach, i.e., maintaining coal plants with a strategy of gradual reduction until they are phased out, indicating a preference for realistic and responsible energy transition policies.

Table 7 The fifth aspect

	Attitude towards policies on the use of fossil fuels as a source of energy	Strongly Agree		Agree		Disagree		Strongly Disagree	
	Statement	f	%	f	%	f	%	f	%
25	The use of coal as a source of electricity in our country needs to be promoted because our country is rich in coal, so that electricity is cheap.	6	15.0	6	15.0	18	45.0	10	25.0
26	The government should inject the death of all coal-fired power plants because they are a source of global warming.	5	12.5	6	15.0	19	47.5	10	25.0
27	The government needs to be wise in the use of coal-fired power plants; they still need to be maintained, but their number should be gradually reduced until it becomes zero in the future.	13	32.5	18	45.0	5	12.5	4	10.0
28	Raids by the police and transportation department on motorized vehicles that emit CO_2 exhaust emissions exceeding the minimum standard need to be intensified.	20	50.0	20	50.0	0	0.0	0	0.0

Furthermore, item 28 showed very high support for concrete policies that can have an immediate impact, namely tightening the monitoring of motor vehicles with high CO_2 emissions. All respondents agreed that monitoring of motor vehicle emissions needs to be tightened, indicating that students are more accepting of direct actions targeting daily activities rather than large-scale policies such as a total coal phase-out. This finding indicates that while students are concerned about global warming issues, they also consider social and economic realities in assessing energy policies. Therefore, a balanced educational approach that combines environmental impact information with an understanding of national energy needs is crucial for developing critical and informed energy literacy among students (e.g., Keller et al., 2022; Maurer & Bogner, 2022).

The majority of students rejected the promotion of using coal as a source of electricity, even though coal is abundant and electricity is cheap, with 18 students disagreeing and 10 students strongly disagreeing, while only 6 students strongly agreed and 6 agreed. A similar attitude emerged on the statement that the government should close all coal-fired power plants as they contribute to global warming; 19 students disagreed and 10 strongly disagreed, while 5 strongly agreed and 6 agreed. However, students were more supportive of a prudent policy, where coal plants are retained but gradually reduced to zero, with 13 students strongly agreeing and 18 agreeing. The strongest and most positive attitude was seen in the statement about the need to intensify raids on motor vehicles that exceed CO_2 emission standards, where all 40 students agreed or strongly agreed. This data shows that students support the policy of phasing out fossil fuels and controlling vehicle pollution as an effort to deal with environmental issues.

RQ6: Attitude towards policies on the use of alternative energy sources for electricity supply

Table 8 shows that the majority of students have a positive attitude towards the utilization of alternative energy, particularly solar power and micro hydro. Items 29 and 33 show

strong agreement with subsidizing the installation of solar panels in households and on top of Cirata Reservoir, reflecting students' understanding of the great potential of solar energy as a clean and efficient solution. In addition, in item 37, students also strongly supported the use of micro-hydro power plants in rural areas. This support is consistent with the view that alternative energy needs to be disseminated according to regional characteristics (Iweh et al., 2021). However, support for the obligation of local governments to provide land for solar panel installation (item 34) was relatively low, indicating students' concerns about the policy's practical and social aspects. In general, students support government incentives for clean energy technologies, including subsidies for the purchase of electric vehicles (item 31) and the construction of solar panel factories in the country (item 32).

Table 8 The sixth aspect

Attitude towards policies on the use of alternative energy sources for the electricity supply		**Strongly Agree**		**Agree**		**Disagree**		**Strongly Disagree**	
	Statement	f	%	f	%	f	%	f	%
29	The government is right to subsidize the installation of solar panels for household electricity.	18	45.0	19	47.5	2	5.0	1	2.5
30	The construction of dams for hydropower needs to be limited as it will submerge many residential and agricultural areas.	2	5.0	7	17.5	17	42.5	14	35.0
31	It is appropriate for the government to subsidize the purchase of electric motorcycles and cars.	13	32.5	15	37.5	7	17.5	5	12.5
32	The government needs to encourage the construction of solar panel factories in the country to make the price more competitive.	14	35.0	17	42.5	5	12.5	4	10.0
33	The installation of solar panels above Cirata Lake is very appropriate to increase the supply of renewable electricity and does not take up land.	16	40.0	22	55.0	2	5.0	0	0.0
34	Every municipality should vacate a portion of its territory to install solar panels to provide a clean source of electricity in its city.	6	15.0	6	15.0	19	47.5	9	22.5
35	It is very appropriate if the government issues a policy on the use of solar panels on rooftops as a source of household electrical energy.	15	37.5	17	42.5	5	12.5	3	7.5
36	The current government policy is to maximize support for the use of clean and renewable energy.	4	10.0	9	22.5	17	42.5	10	25.0
37	Micro-hydro power plants are a good solution for rural areas.	18	45.0	18	45.0	3	7.5	1	2.5
38	The safety of nuclear power plants can be guaranteed with the right technology and supervision.	13	32.5	14	35.0	6	15.0	7	17.5

Attitude towards policies on the use of alternative energy sources for the electricity supply		Strongly Agree		Agree		Disagree		Strongly Disagree	
39	The construction of nuclear power plants does not require public support because it poses significant risks to the community.	7	17.5	7	17.5	14	35.0	12	30.0
40	The government needs to continue providing the public with an understanding that nuclear power plants are a clean and safe source of energy that can supply a substantial amount of electricity.	12	30.0	16	40.0	7	17.5	5	12.5

Meanwhile, students' attitudes toward nuclear energy remain divided. Items 38 and 40 show moderate support for the view that nuclear power plants (NPPs) are safe if monitored with appropriate technology and can serve as a source of clean electricity. However, a portion of students still perceive NPPs as dangerous and believe they do not require public support (item 39), reflecting an ambivalence influenced by risk perception. In addition, students expressed relatively low agreement with the notion that current government policies have sufficiently supported renewable energy development (item 36), indicating a need for improved public communication and policy transparency. These findings suggest that while students are generally supportive of alternative energy sources, they also advocate for policy approaches that are inclusive, educational, and realistic in order to enhance public acceptance and understanding of clean energy technologies, including those that are controversial, such as nuclear energy. This aligns with previous studies that highlight the importance of energy literacy in shaping informed and rational public opinion (Cotton et al., 2016; Daoudi, 2024; DeWaters & Powers, 2013). These studies emphasize that comprehensive education on energy sources, their environmental impacts, and their socio-economic and safety dimensions is crucial for fostering a society capable of making wise and participatory energy decisions. Accordingly, students' support for alternative energy reflects not only environmental awareness but also aspirations for knowledge-based and socially just energy policies.

The majority of students supported subsidizing the installation of solar panels at home, with 18 students strongly agreeing and 19 agreeing. They also agreed to construct a solar panel factory to reduce prices and to install panels at Lake Cirata as a source of clean electricity. Microhydro power generation for rural areas also received strong support. However, the construction of dams for hydropower plants was rejected because it could drown settlements and agricultural land. Electric vehicle subsidies also received a positive response. The majority of students supported the policy of using solar panels on rooftops. Attitudes towards nuclear plants vary; some believe that safety can be maintained, but others are concerned and reject nuclear construction. In general, students support the use of renewable energy sources, such as solar and microhydro, but remain wary of nuclear plants and large dams, indicating a need for further education on the benefits and risks of each energy source.

RQ7: Attitude towards the issue of the impact of global warming

Table 9 shows that students' attitudes towards the impact of global warming are quite varied, with most students recognizing the relationship between the phenomenon and the environmental events that occur. In items 42 and 44, the majority of students agreed that

the narrowing of the land area in the low region and the reduced volume of ice on Mount Jaya Wijaya are clear evidence of global warming. This indicates that students are aware of the impact of global warming, which is already being felt in some areas. Additionally, in item 43, there is an understanding that flash floods and droughts are closely related to global warming, although some students still doubt this connection, given the complex weather conditions and numerous other factors that influence these events.

Table 9 The seventh aspect

Attitude towards the issue of the impact of global warming		Strongly Agree		Agree		Disagree		Strongly Disagree	
	Statement	f	%	f	%	f	%	f	%
41	The occurrence of tidal floods in some areas of the north coast of Java is not necessarily caused by the phenomenon of global warming.	13	32.5	16	40.0	6	15.0	5	12.5
42	The narrowing of the island's land area in the lowlands is clear evidence of global warming.	16	40.0	18	45.0	4	10.0	2	5.0
43	Flash floods and droughts are closely related to the phenomenon of global warming.	13	32.5	15	37.5	6	15.0	6	15.0
44	The decreasing volume of ice at the top of Mount Jaya Wijaya is clear evidence of the phenomenon of global warming.	16	40.0	20	50.0	2	5.0	2	5.0
45	The recent heatwave that affected several countries highlights the rise in air temperature attributed to global warming.	6	15.0	8	20.0	14	35.0	12	30.0

However, some students still doubted or did not attribute some events to global warming. For example, in item 41, students were divided in their perception of the link between tidal flooding on the north coast of Java and global warming, with most not fully agreeing that the phenomenon was caused by global warming. The same was the case for item 45, where only a minority of students considered heat waves as evidence of increasing air temperatures due to global warming. This suggests that while students are generally aware of the impacts of global warming, there are gaps in their understanding of the relationship between global warming and extreme weather events, which may be due to a lack of understanding of the complexities of climate change (Kafi et al., 2024; Raymond et al., 2020; Sánchez-Almodóvar et al., 2022).

Most students acknowledged the impact of global warming, especially in relation to the shrinking of island land in low-lying areas (16 strongly agree, 18 agree) and the decreasing volume of ice at the top of Mount Jaya Wijaya as clear evidence of this phenomenon (16 strongly agree, 20 agree). Students also tend to attribute flash floods and droughts to global warming (13 strongly agree, 15 agree). However, there was doubt on the link between tidal flooding on the north coast of Java and global warming, with 13 students strongly agreeing that such flooding is not always caused by global warming and 16 students agreeing with this statement. Regarding the recent heatwaves in some countries, students' attitudes were more divided; only 6 students strongly agreed and 8 agreed, while 14 students disagreed and 12 strongly disagreed that the phenomenon was due to global warming. This data shows a fairly good understanding of the impact of global warming, but some aspects still need clarification.

CONCLUSION

Based on the study's results, it can be concluded that students have a fairly high awareness of the issue of global warming and its impacts, although there are still differences in their understanding of the direct link between extreme weather events and the phenomenon. They support the integration of global warming material in physics learning, with evidence-based and practical approaches, and support clean energy policies, such as solar power. However, there are differences in views regarding policies on the use of fossil and nuclear energy, with a tendency to favor reducing dependence on energy sources that have the potential to damage the environment. A limitation of this study is that the sample is limited to students in one region, which may limit the generalizability of the results to a wider population. Suggestions for future research include expanding the sample and incorporating more variables that influence students' attitudes towards global warming. In addition, it is crucial to continue introducing the concept of climate change and renewable energy-based solutions in the education curriculum, as well as developing more inclusive and evidence-based policies to address the issue of global warming. In addition, this study highlights the important roles of educators and policymakers in fostering not only knowledge but also positive attitudes and active engagement among students toward environmental sustainability. Implementing targeted project-based interventions and continuously monitoring student attitudes can help ensure more effective climate education and promote long-term behavioral change.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, BEP and ASH; methodology, LA; formal analysis, BEP; writing—preparation of the original draft, MZBA and KN; writing review and proofreading, KN; supervision, ASH and LA.

ACKNOWLEDGMENTS

The authors would like to express their gratitude to Universitas Pendidikan Indonesia for providing academic support and facilities that contributed to the completion of this research.

REFERENCES

Abbass, K., Qasim, M. Z., Song, H., Murshed, M., Mahmood, H., & Younis, I. (2022). A review of the global climate change impacts, adaptation, and sustainable mitigation measures. *Environmental Science and Pollution Research*, *29*(28), 42539–42559.

Abbott, M. L. (2016). *Using statistics in the social and health sciences with SPSS and excel*. John Wiley & Sons.

Alan, Ü., & Kabasakal, K. A. (2020). Effect of number of response options on the psychometric properties of Likert-type scales used with children. *Studies in Educational Evaluation*, *66*, 100895.

Algurén, B. (2021). How to bring about change–a literature review about education and learning activities for sustainable development. *Discourse and Communication for Sustainable Education*, *12*(1), 5–21.

Amiruddin, M. Z. Bin, Samsudin, A., Suhandi, A., Kaniawati, I., COŞTU, B., Aminuddin, A. H., & Kuniawan, F. (2023). Validity and reliability of the global warming instrument: a pilot study using rasch model analysis. *Jurnal Pendidikan MIPA*, *24*(4), 912–922.

Barzilai, S., & Chinn, C. A. (2020). A review of educational responses to the “post-truth”

condition: Four lenses on "post-truth" problems. *Educational Psychologist*, *55*(3), 107–119.

Boon, H. J. (2010). Climate change?: Who knows?: A comparison of secondary students and pre-service teachers. *Australian Journal of Teacher Education (Online)*, *35*(1), 104–120.

Bright, M. L., & Eames, C. (2022). From apathy through anxiety to action: Emotions as motivators for youth climate strike leaders. *Australian Journal of Environmental Education*, *38*(1), 13–25.

Canlas, I. P., & Kazakbaeva, R. (2023). Interdisciplinary approach to climate change education. In *University Initiatives on Climate Change Education and Research* (pp. 1–19). Springer.

Cotton, D., Miller, W., Winter, J., Bailey, I., & Sterling, S. (2016). Knowledge, agency and collective action as barriers to energy-saving behaviour. *Local Environment*, *21*(7), 883–897.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

da Rosa, J. A. (2022). Comparing climate science misconceptions with worldview and cognitive reflection suggests poor understanding and motivated reasoning among undergraduates. *Journal of Geoscience Education*, *70*(4), 501–516. https://doi.org/10.1080/10899995.2021.2006549

Daoudi, M. (2024). Education in renewable energies: A key factor of Morocco's 2030 energy transition project. Exploring the impact on SDGs and future perspectives. *Social Sciences & Humanities Open*, *9*, 100833.

DeWaters, J., & Powers, S. (2013). Establishing measurement criteria for an energy literacy questionnaire. *The Journal of Environmental Education*, *44*(1), 38–55.

Eslen-Ziya, H. (2022). Humour and sarcasm: expressions of global warming on Twitter. *Humanities and Social Sciences Communications*, *9*(1), 1–8.

Glavič, P. (2020). Identifying key issues of education for sustainable development. *Sustainability*, *12*(16), 6500.

Handayani, R. D., & Putra, P. D. A. (2019). Student cognition in the context of a climate system: Global warming and greenhouse effect. *Momentum: Physics Education Journal*, 69–77.

Handayani, R. D., & Triyanto. (2022). Seventh-grade students' conceptions of climate change, global warming, and the greenhouse effect. *Journal of Geoscience Education*, *70*(4), 490–500.

Hansen, J. E., Sato, M., Simons, L., Nazarenko, L. S., Sangha, I., Kharecha, P., Zachos, J. C., von Schuckmann, K., Loeb, N. G., & Osman, M. B. (2023). Global warming in the pipeline. *Oxford Open Climate Change*, *3*(1), kgad008.

Hari, V., Rakovec, O., Markonis, Y., Hanel, M., & Kumar, R. (2020). Increased future occurrences of the exceptional 2018–2019 Central European drought under global warming. *Scientific Reports*, *10*(1), 12207.

Herman, B. C., Newton, M. H., & Zeidler, D. L. (2021). Impact of place-based socioscientific issues instruction on students' contextualization of socioscientific orientations. *Science Education*, *105*(4), 585–627.

Iweh, C. D., Gyamfi, S., Tanyi, E., & Effah-Donyina, E. (2021). Distributed generation and renewable energy integration into the grid: Prerequisites, push factors, practical options, issues and merits. *Energies*, *14*(17), 5375.

Jarrett, L., & Takacs, G. (2020). Secondary students' ideas about scientific concepts underlying climate change. *Environmental Education Research*, *26*(3), 400–420.

Jehanzaib, M., Shah, S. A., Yoo, J., & Kim, T.-W. (2020). Investigating the impacts of

climate change and human activities on hydrological drought using non-stationary approaches. *Journal of Hydrology*, *588*, 125052.

Kafi, K. M., Ponrahono, Z., & Salisu Barau, A. (2024). Addressing knowledge gaps on emerging issues in weather and climate extreme events: a systematic review. *Climatic Change*, *177*(3), 56.

Keller, L., Riede, M., Link, S., Hüfner, K., & Stötter, J. (2022). Can education save money, energy, and the climate?—assessing the potential impacts of climate change education on energy literacy and energy consumption in the light of the EU energy efficiency directive and the Austrian energy efficiency act. *Energies*, *15*(3), 1118.

Kumar, U. (2023). *Global warming, climate change and environment*. Guarav book center.

Kurup, P. M., Levinson, R., & Li, X. (2021). Informed-decision regarding global warming and climate change among high school students in the United Kingdom. *Canadian Journal of Science, Mathematics and Technology Education*, *21*, 166–185.

Lee, H., & Yang, J. (2019). Science teachers taking their first steps toward teaching socioscientific issues through collaborative action research. *Research in Science Education*, *49*(1), 51–71.

Lee, H., Yoo, J., Choi, K., Kim, S.-W., Krajcik, J., Herman, B. C., & Zeidler, D. L. (2013). Socioscientific issues as a vehicle for promoting character and values for global citizens. *International Journal of Science Education*, *35*(12), 2079–2113.

Maurer, M., & Bogner, F. X. (2022). Green awareness in action of saving energy in school life: Modeling environmental literacy in theory and practice experience. In *Handbook of Climate Change Mitigation and Adaptation* (pp. 3531–3556). Springer.

Mhlongo, H. R. (2024). Addressing global warming issues in schools through curriculum integration. *International Journal of Innovative Technology and Interdisciplinary Sciences*, *7*(3), 115–136.

Muslihin, H. Y., Suryana, D., Suherman, U., & Dahlan, T. H. (2022). Analysis of the reliability and validity of the self-determination questionnaire using rasch model. *International Journal of Instruction*, *15*(2), 207–222.

Palmucci, D. N., & Ferraris, A. (2023). Climate change inaction: Cognitive bias influencing managers' decision making on environmental sustainability choices. The role of empathy and morality with the need of an integrated and comprehensive perspective. *Frontiers in Psychology*, *14*, 1130059.

Pambudi, N. A., Nanda, I. R., Alfina, F. T., & Syahrial, A. Z. (2024). Renewable energy education and awareness among Indonesian students: Exploring challenges and opportunities for a sustainable future. *Sustainable Energy Technologies and Assessments*, *63*, 103631.

Perwithosuci, W., Chayyani, N. R., & Abidin, A. Z. (2023). Youth perception on climate change: a study in Central Java, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *1180*(1), 12049.

Rahman, M. M., Tabash, M. I., Salamzadeh, A., Abduli, S., & Rahaman, M. S. (2022). Sampling techniques (probability) for quantitative social science researchers: a conceptual guidelines with examples. *Seeu Review*, *17*(1), 42–51.

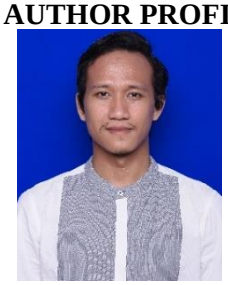
Raymond, C., Horton, R. M., Zscheischler, J., Martius, O., AghaKouchak, A., Balch, J., Bowen, S. G., Camargo, S. J., Hess, J., & Kornhuber, K. (2020). Understanding and managing connected extreme events. *Nature Climate Change*, *10*(7), 611–621.

Rodríguez-Hernández, C. F., Cascallar, E., & Kyndt, E. (2020). Socio-economic status and academic performance in higher education: A systematic review. *Educational Research Review*, *29*, 100305.

Sánchez-Almodóvar, E., Gómez-Trigueros, I. M., & Olcina-Cantos, J. (2022). Climate change and extreme weather events in the education of the citizens of the twenty-first

century: The perception of secondary education students. *Social Sciences*, *12*(1), 27.
Schauss, M., & Sprenger, S. (2021). Students' conceptions of uncertainties in the context of climate change. *International Research in Geographical and Environmental Education*, *30*(4), 332–347.
Sharma, S., Sharma, V., & Chatterjee, S. (2023). Contribution of plastic and microplastic to global climate change and their conjoining impacts on the environment-A review. *Science of the Total Environment*, *875*, 162627.
Supriatna, A., Tias, B., Hendayana, S., & Hernani, H. (2024). Global warming: Promoting environmental awareness of senior secondary school students facing issues in the sustainable development goals (Sdgs). *Journal of Engineering Science and Technology*, *19*(3), 1048–1064.
Suratmi, S., Laihat, L., Pulungan, M., Aswasulasikin, A., Rahma, N. T., & Utami, L. A. (2025). Profile of Enviromental Literacy of Students on the Topic of Renewable Energy. *Jurnal Penelitian Pendidikan IPA*, *11*(3).
Syropoulos, S., & Markowitz, E. (2024). Responsibility towards future generations is a strong predictor of proenvironmental engagement. *Journal of Environmental Psychology*, *93*, 102218.
Trott, C. D. (2020). Children's constructive climate change engagement: Empowering awareness, agency, and action. *Environmental Education Research*, *26*(4), 532–554.
Trott, C. D., & Weinberg, A. E. (2020). Science education for sustainability: Strengthening children's science engagement through climate change learning and action. *Sustainability*, *12*(16), 6400.
Varela, B., Sesto, V., & García-Rodeja, I. (2020). An investigation of secondary students' mental models of climate change and the greenhouse effect. *Research in Science Education*, *50*, 599–624.
Winter, V., Kranz, J., & Möller, A. (2022). Climate change education challenges from two different perspectives of change agents: Perceptions of school students and pre-service teachers. *Sustainability*, *14*(10), 6081.
Yilmaz, V., & Can, Y. (2020). Impact of knowledge, concern and awareness about global warming and global climatic change on environmental behavior. *Environment, Development and Sustainability*, *22*(7), 6245–6260.

AUTHOR PROFILES



Full Name Bayu Eka Putra
Email bayuekaputra@upi.edu
Expertise Physics Education
Affiliation Universitas Pendidikan Indonesia

Full Name : Andi Suhandi
Email : Andi_sh@upi.edu
Expertise : Material Physics, Physics Education, Mental Model, Conceptual Change, Asessment
Affiliation : Universitas Pendidikan Indonesia
Google Scholar : ANDI SUHANDI - Google Scholar
Sinta : https://sinta.kemdikbud.go.id/authors/profile/6005865
Orcid : https://orcid.org/0000-0001-9912-7308

Scopus links : Suhandi, Andi - Author details - Scopus Preview

Full Name : Lina Aviyanti
Email : lina@upi.edu
Expertise : Assessment in Physics Education
Affiliation : Universitas Pendidikan Indonesia
Google Scholar : https://scholar.google.com/citations?user=GzsGTqsAAAAJ&hl=en
Sinta : https://sinta.kemdikbud.go.id/authors/profile/6735786
Orcid : https://orcid.org/0000-0003-1152-9703
Scopus ID 57193869963

Full Name : Mohd Zaidi Bin Amiruddin
Email : mohdzaidi@upi.edu
Expertise : Physics Education, Conceptual Change, Mental Model, Bibliometric analysis
Affiliation : Universitas Pendidikan Indonesia
Google Scholar : https://scholar.google.com/citations?hl=en&user=o8ZS2UkAAAAJ
Orcid : https://orcid.org/0000-0001-9814-5782
Scopus links : https://www.scopus.com/authid/detail.uri?authorId=36760394200

Full Name : Khoirun Nisa'
Email : 611388112@gms.ndhu.edu.tw
Expertise : Physics education, STEAM, Bibliometric analysis, Multicultural education
Affiliation : National Dong Hwa University
Google Scholar : https://scholar.google.com/citations?hl=en&user=z3eU3xkAAAAJ
Orcid : https://orcid.org/0000-0003-2140-2642
Scopus ID : 57656277400