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Original Research Article

Assessments of Climate Literacy and Climate Change Awareness

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Abstract
Climate change has become a serious threat to all humans, with impacts already being felt throughout the planet. One effort in climate change education is to improve students' climate literacy and climate change awareness. This study aims to measure climate literacy and climate change awareness of vocational high school students and analyze the relationship between aspects of these two variables. The instrument used was a questionnaire with a 5-point Likert scale processed with descriptive statistics and Pearson correlation analysis. The results from 295 respondents showed that the average climate literacy was in the high category (3.50), while climate change awareness was in the medium category (3.40). However, both showed significant gaps in each aspect. The results of the correlation analysis showed a significant relationship between attitudes and behavior, both in climate literacy (r = 0.323) and climate change awareness (r = 0.142). Climate change education not only conveys information in the form of knowledge but also includes efforts to strengthen attitudes that can encourage sustainable climate-friendly behavior. The results of this study will be the basis for developing climate change teaching materials in vocational high schools to improve students' climate literacy and climate change awareness.

Keywords: Climate change; climate change education; climate literacy; climate change awareness

1. Introduction

Climate change has now become a serious threat to global society, ecosystems, and the very fabric of life on earth (Assaraf et al., 2024). The impacts of climate change are now increasingly worrying, threatening not just one location, but entire regions on planet Earth. In Sumedang Regency, a hydrometeorological disaster, a puting beliung that destroyed hundreds of homes on the Sumedang-Bandung border in early 2024, is indicated to be related to climate change (Saputra, 2024). From June to August 2024, Climate Central listed Sumedang as one of the five cities with the highest temperatures in Southeast Asia (Aisyah, 2024). A water crisis has also begun to occur in Sumedang Regency, with 200 families in the Ujungjaya area experiencing a shortage of clean water every dry season (Sumaryadi, 2024), and 255 families in the Margamukti area requesting clean water assistance from the Regional Disaster Management Agency (Yusuf, 2024). Climate change is the responsibility of all humankind on planet Earth. Improving climate literacy is essential for climate change mitigation and adaptation (Cooper et al., 2019). Likewise, climate change awareness needs to be increased to address the challenges of climate change (Kuthe et al., 2019). Climate literacy provides an understanding of how the climate system works, how human actions affect the climate, and vice versa (USGCRP, 2024). Climate change awareness, on the other hand, refers to concern and belief in climate change issues (Jürkenbeck et al., 2021).

Education plays three crucial roles in climate issues: first, empowering people to build awareness for mitigation; second, building human adaptability to the existing climate crisis; and third, encouraging sustainable learning related to the climate crisis (BSKAP, 2024). However, studies show that climate change education in Indonesia has not been prioritized in either general or educational policies (Tang,

2024). Furthermore, UNESCO's Global Education Monitoring Report states that there are no teaching materials available in Indonesia specifically addressing climate change (UNESCO, 2021). Yet, teaching materials are crucial in learning activities, serving to facilitate the teaching and learning process by making learning more engaging and practical (Azizah et al., 2022).

Research related to the development of climate change teaching materials includes the development of interactive modules for seventh-grade junior high school students, which have been shown to improve students' ecological literacy (Rubini et al., 2023). Furthermore, the development of low-carbon education e-books using the ESD framework on climate change has been shown to improve junior high school students' sustainability literacy (Warliyah et al., 2023). Finally, the development of a flipped classroom-based blended learning e-module on climate change has been shown to improve the digital literacy skills of seventh-grade junior high school students (Mufidah et al., 2023). There have been no studies on the development of climate change teaching materials aimed at improving climate literacy and climate change awareness, especially at the vocational high school level. Environmental education, such as climate change, in vocational high schools is important as a foundation for increasing awareness and sustainable action in addressing ecological challenges in the future workplace (Prasetyo and Jupri, 2024).

This study aims to measure climate literacy and climate change awareness among vocational high school students in Sumedang Regency and investigate the relationship between aspects of both variables, namely knowledge, attitudes, and behavior. The measured profiles of climate literacy and climate change awareness will be used as a basis for developing effective teaching materials to improve both variables.

2. Methods

The research method used was descriptive research, aiming to describe students' climate literacy and climate change awareness based on the data obtained. This study used a questionnaire containing 18 questions/statements. The questionnaire used a Likert scale of 1 to 5. Indicators of climate literacy and climate change awareness are presented in Table 1.

Table 1. Climate literacy and climate change awareness grid

Variable	Aspect	Indicator
Climate literacy	Knowledge	1. Knowledge of climate system science
		2. Understanding the impacts and threats of climate change
	Attitude	3. Motivation to make appropriate mitigation and adaptation decisions
	Behavior	4. Communicating climate change
Climate change awareness	Knowledge	1. Knowledge
	Behavior	2. Climate friendly behavior
		3. Multiplicative action
	Attitude	4. Attitude
		5. Personal concern

The subjects in this study were 295 tenth-grade vocational high school students, consisting of 223 males and 72 females. The data analysis technique used was descriptive statistical analysis, which provides a description of the research object through sample data as it is. The questionnaire results were processed into a score of 1 to 5, taking into account both positive and negative statements. To determine the average score for climate literacy and climate change awareness, the following calculations (1) were used:

$$Score\ Range = \frac{Highest\ score - Lowest\ Score}{Number\ of categories} \quad (1)$$

The categories of climate literacy and climate change awareness are interpreted based on the average scores in the following table

Table 2. Score category

Score Range	Category
1.00 – 1.80	Very low
1.81 – 2.60	Low
2.61 – 3.40	Enough
3.41 – 4.20	High
4.21 – 5.00	Very high

The correlation between knowledge, attitudes, and behavior aspects in climate literacy and climate change awareness was calculated using the product-moment correlation formula if the data were normally distributed and the Spearman correlation formula if they were not. The level of correlation and the strength of the relationship were determined based on Table 3.

Table 3. Correlation value and level

Correlation value	Correlation level
0.000 – 0.199	Very weak
0.200 – 0.399	Weak
0.400 – 0.990	Enough
0.600 – 0.799	Strong
0.800 – 1.000	Very strong

3. Result and Discussion

3.1. Student Climate Literacy

The distribution of questionnaire responses regarding climate literacy from 295 respondents is presented in Table 4.

Table 4. Distribution of climate literacy questionnaire

No	Indicator	Item	Score 5	Score 4	Score 3	Score 2	Score 1
1	Knowledge of climate system science	1	139	79	58	16	3
		2	131	60	74	20	10
2	Understanding the impacts and threats of climate change	3	232	12	26	18	7
		4	187	41	41	10	16
3	Motivation to make appropriate mitigation and adaptation decisions	7	15	16	112	107	55
		8	49	4	85	59	38
4	Communicating climate change	9	31	126	124	12	2
		10	7	13	32	89	104

In the knowledge aspect of the climate literacy questionnaire, the majority of respondents scored at the maximum, namely 5. This maximum score distribution was more prevalent in the indicator of understanding the impacts and threats of climate change compared to the indicator of knowing the climate system. This indicates that respondents have a better understanding of the impacts and threats of climate change compared to the climate system, which involves more abstract scientific processes such as atmospheric circulation, the carbon cycle, and several key interrelated factors. Meanwhile, the impacts and threats of climate change are concrete and directly felt in students' daily lives. This is consistent with

the results of Wildbichler's (2025) study that students' knowledge of climate system science is limited due to the difficulty in integrating systemic knowledge with real-life contexts.

In contrast to the knowledge aspect, the attitude aspect of climate literacy, with its motivation indicator for making appropriate mitigation and adaptation decisions, saw the highest distribution of questionnaire scores at a score of 3. Respondents with the maximum score were very few. Similarly, in the behavioral aspect, namely communicating climate change, most respondents' scores were not at the maximum score. In fact, the distribution of scores in the behavioral aspect was at a lower score than the attitude aspect. The results of data processing on the climate literacy questionnaire showed a gap in the distribution of questionnaire answers in the knowledge aspect compared to the attitude and behavior aspects. The average score of students' climate literacy can be seen in Figure 1.

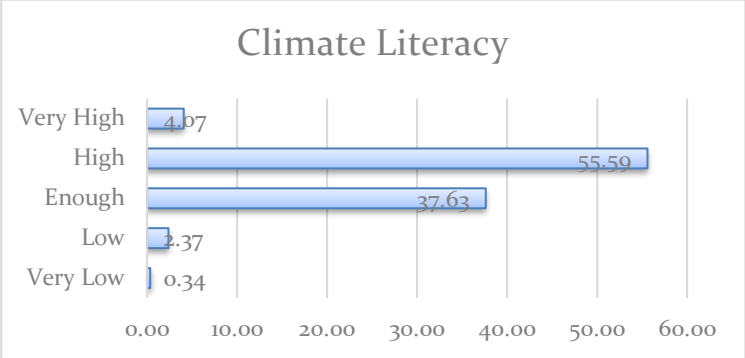

Figure 1. Student climate literacy

The average student's climate literacy was mostly in the good category, followed by the sufficient category. The remaining, in very small numbers, were in the fairly high, low, and very low categories. Today's students live in a digital age with easy access to information from various media, including social media. They can access climate information from various social media platforms without having to wait for the material to be taught in school. Social media has become a favorite source of information for important issues such as climate change. One of the most frequently visited platforms due to its easy-to-access climate information is YouTube (Becerra et al., 2020). More than 2 billion users with varying levels of scientific literacy visit the site. The average climate literacy scores of most students were in the good category, but an analysis of each indicator revealed a very interesting finding.

Table 5. Climate literacy indicator categories

No	Aspect	Indicator	Average	Category
1	Knowledge	Knowledge of climate system science	4.05	High
2	Knowledge	Understanding the impacts and threats of climate change	4.39	Very High
3	Attitude	Motivation to make appropriate mitigation and adaptation decisions	2.76	Enough
4	Behavior	Communicating climate change	2.82	Enough
Climate literacy			3.50	High

Table 5 shows that the average climate literacy scores for each indicator varied. The knowledge aspect showed a high average, while the attitudes and behavior aspects still showed a fair average. There is a gap between the knowledge aspect of climate literacy and the attitudes and behavior aspects. Climate literacy encompasses competencies consisting of knowledge of climate system science and an understanding of the impacts and threats of climate change, attitudes in the form of motivation to make

appropriate decisions to implement mitigation and adaptive solutions to the climate crisis, and behaviors related to communicating about climate change. Therefore, this gap between aspects of climate literacy is unacceptable.

The relationship between environmental knowledge and pro-environmental attitudes or behavior has been widely studied. Some studies have found that a person's environmental knowledge directly influences attitudes and actions, but other research has shown that increasing knowledge alone is not sufficient to change attitudes and behavior (Colombo et al., 2023). In recent decades, scientific understanding of climate change has increased rapidly but has not been accompanied by increased action (Knutti, 2019).

Extensive research has been conducted on the causes of the gap between environmental knowledge and pro-environmental attitudes and behavior. This gap is caused by several factors, one of which is that direct experience has a stronger influence on behavior. Students who only learn about climate change from textbooks or school lessons may not necessarily develop positive pro-environmental attitudes and behavior compared to students who experience it directly in their lives. Another factor is family habits, social norms, or prevailing culture that usually influence a person's attitudes and behavior more than the knowledge they acquire. For example, knowledge about waste sorting will not influence attitudes and behavior at home if all family members are accustomed to having only one trash can.

The gaps that exist in these three aspects of climate literacy must certainly be minimized. To determine the right solution for fostering students' pro-environmental behavior towards climate change, an analysis of the relationships between these three aspects of climate literacy was conducted, as shown in Table 6.

Table 6. The relationship between aspects of climate literacy

No	Correlation	Level of significance	Pearson correlation	Relationship level
1	Knowledge with attitudes	0.505	0.039	Very weak
2	Knowledge with behavior	0.420	-0.047	Very weak
3	Attitudes with behavior	<0.001	0.323	Weak

A qualified level of significance was found only for the relationship between attitudes and behavior. Despite the weak correlation, the relationship between these two aspects was the strongest among the other aspects. Efforts to improve climate literacy should focus not only on increasing knowledge but also on improving students' attitudes toward climate change. Attitude is a mediator between knowledge and behavior (Kollmus and Agyeman, 2022). Strengthening attitudes in climate change learning can provide an opportunity to transform knowledge into sustainable behavior.

Furthermore, attitudes are also a determining factor in one's intentions and behavior. Developing a positive attitude toward climate change will play a crucial role in encouraging climate action (Tang, 2022). During the learning process, students can be guided to explore the impacts of climate change on their environment and identify climate-related problems they encounter. Students are also guided to plan and develop alternative solutions. Such learning activities will foster students' desire to address problems and lead to action.

3.2. Climate Change Awareness

Similar to climate literacy, climate change awareness comprises aspects of knowledge, attitudes, and behavior. To determine students' answers and responses, an analysis of the instrument results from 295 respondents was conducted, as shown in Table 7.

Table 7. Distribution of climate change awareness questionnaire

No	Indicator	Item	Score 5	Score 4	Score 3	Score 2	Score 1
1	Knowledge	5	151	27	91	16	10
		6	210	9	14	40	22
2	Climate friendly behavior	11	212	49	25	7	2
		12	37	56	135	54	13
3	Multiplicative action	13	22	32	89	73	79
		14	25	25	96	67	82
4	Attitude	15	24	111	121	35	4
		16	8	49	135	90	13
5	Personal concern	17	58	186	47	2	2
		18	9	41	155	72	18

The distribution of respondents' responses for the knowledge aspect of climate change awareness is similar to the distribution for climate literacy, with the highest score being 5. The difference is that while the knowledge aspect of climate literacy is objective and based on scientific evidence, the knowledge aspect of climate change awareness is more subjective and influenced by psychological-social factors (Kahan et al., 2012). This knowledge aspect of climate change awareness will be the basis for someone to make the right decisions regarding climate change.

The results of the climate change awareness questionnaire also revealed a gap in attitudes and behavior. In the attitude aspect, the distribution of respondents' answers was not at the maximum score. Respondents' scores were mostly distributed between 3 and 4. This attitude aspect encompasses a positive attitude toward climate change as well as sensitivity and concern for the climate change that has occurred. A positive attitude relates to one's responsibility towards climate change and the perception that behavioral changes will have a positive impact on climate change. The distribution of respondents' scores indicates a lack of positive attitudes and responsibility among students, despite their strong knowledge as a basis for climate change awareness.

The distribution of respondents' scores on the behavioral aspect is also interesting to analyze. Climate-friendly behaviors show a greater distribution of high scores compared to multiple actions. New students demonstrate good climate-friendly behaviors only in their own lives, they are not yet able to invite those around them to do the same. Becoming an agent of change certainly requires greater effort and significant obstacles. Many factors influence someone's ability to become an agent of change, one of which is psychological factors such as self-confidence, which certainly contributes significantly. Research shows that negative emotions drive daily behavior by 70-80%, but drive behavior involving others by 20-30%. To bridge the gap between attitudes and behavior, habituating small actions must be continuously practiced to build momentum towards larger actions (Ballew et al., 2024). The average score of students' climate change awareness can be seen in Figure 1.

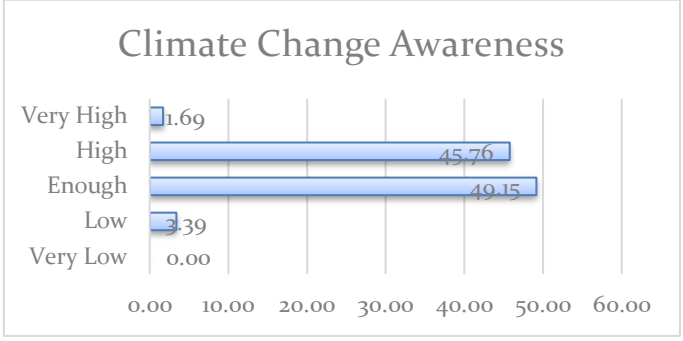

Figure 2. Student climate change awarenes

Compared to climate literacy, students' awareness of climate change scores were lower, with the majority falling within the adequate category. The average scores for each indicator clearly demonstrate the gap between knowledge and attitudes and behavior, as shown in Table 8 below.

Table 8. Climate change awareness indicator categories

No	Aspect	Indicator	Average	Category
1	Knowledge	Knowledge	4.08	High
2	Behavior	Climate friendly behavior	3.87	High
3	Behavior	Multiplicative action	2.49	Low
4	Attitude	Attitude	3.12	Enough
5	Attitude	Personal concern	3.42	High
Climate change awareness			3.40	Enough

The average score for the knowledge aspect showed the highest value, with significant gaps in behavior and attitudes. High levels of knowledge do not guarantee strong pro-environmental attitudes and behaviors, especially when it comes to multiple actions. Besides knowledge, other factors, such as emotions, play a crucial role in the transition from knowledge to attitudes and behavior. Negative emotions, such as anxiety, stimulate positive attitudes and transform them into personal behaviors, but they don't replicate (Kovacs et al., 2024). Furthermore, an individual's personal experiences can also influence a person's awareness. It's no surprise that individuals with high levels of knowledge sometimes have ambiguous attitudes and rarely engage in various actions.

To strengthen the basis for taking appropriate solutions for improving students' pro-environmental behavior, an analysis of the relationship between knowledge aspects and attitudes and behavior aspects on climate change awareness is presented in Table 9.

Table 9. The relationship between aspects of climate change awareness

No	Correlation	Level of significance	Pearson correlation	Relationship level
1	Knowledge with attitudes	0.060	0.109	Very weak
2	Knowledge with behavior	0.277	0.063	Very weak
3	Attitudes with behavior	0.015	0.142	Very weak

Similar to climate literacy, there was a significant relationship between attitudes and behavior, but the correlation coefficient was smaller. This suggests a link between attitudes and behavior in the climate context, a common finding in previous research. Unlike abstract knowledge, attitudes directly drive action. Positive climate-related emotions, such as hope or empathy, strengthen the transition from attitudes to behavior. According to the theory of planned behavior, attitudes will influence intentions, which then become behavior if supported by social norms and self-efficacy, such as the belief that one can succeed (Palupi and Sawitri, 2015).

3.3. Climate Change Education

Climate change education encompasses the process of understanding climate change events, adapting to existing climate change, and taking actions to mitigate its impacts (Rocha et al., 2020). In formulating climate change education, it is necessary to understand the nature of climate change education, integrating it with various findings in the field, such as the state of climate literacy and student awareness of climate change.

Knowledge of climate change encompasses several fields, including natural science, social science, political science, and economics. The natural sciences aspect encompasses the natural and anthropogenic causes of climate change, the fundamentals of the climate system, the ecological impacts of climate change, and climate change adaptation and mitigation. The social sciences aspect encompasses the social impacts of climate change on communities, food security, water availability, and health. The political aspect encompasses international movements and agreements that support climate change adaptation and mitigation actions. The economic aspect is described as the impact of climate change on the economy. The development of climate change teaching materials must, of course, encompass all of these aspects.

In addition to developing effective climate change teaching materials, classroom implementation requires the use of effective approaches and models. A literature review revealed that appropriate learning approaches for climate change education are student-centered, interdisciplinary, phenomenon-based, and capable of creating meaningful learning experiences. Evidence-based and scientific learning can be used to convince students of the importance of climate change education (Monroe et al., 2019). Appropriate learning models for climate change education include active learning models such as inquiry-based learning, problem-based learning, project-based learning, and game-based learning, all of which require thorough preparation (Cintami et al., 2025). Effective climate change learning is implemented through project-based learning because it is student-centered and fosters authentic student participation.

To increase pro-environmental behavior, climate change education development is not only carried out at the individual level but also involves students in their communities, such as through co-curricular and extracurricular activities. Students are involved in community projects and are expected to empower others with what they have learned. Students are given project contexts that are relevant to their daily lives. Contextual learning with local examples is an excellent way to give relevance and meaning to a concept.

Climate change is a complex topic and must be adapted to the age and development of students. Students in the 5-9 age group think concretely and learn through experience. Appropriate learning activities include small group learning so that each student can have an even learning experience. Students in the 10-12 age group are full of curiosity and want to learn unique facts about how things work. Providing comprehensive information resources will greatly assist in climate change education for these students. Students in the 13-15 age group are able to process from concrete information to more abstract thinking. This group is ready to undertake investigative learning activities and engage in abstract thinking. The final group, high school or vocational school students, can be given activities to plan their own projects with guidance provided as needed.

4. Conclusions

This study, involving 295 vocational high school students in Sumedang, aimed to measure their levels of climate literacy and climate change awareness. Findings indicate that the average climate literacy score is in the good category (3.50) and climate change awareness is in the fair category (3.40). However, analysis of each indicator reveals a gap between knowledge and attitudes and behavior in both climate literacy and climate change awareness. A good understanding of climate issues does not directly influence positive attitudes that can subsequently lead to concrete environmental action.

Analysis of the relationship between the three aspects of climate literacy and climate change awareness shows a significant correlation between attitudes and behavior. Attitude acts as a crucial bridge, with a stronger relationship to behavior than knowledge. This emphasizes the need for a climate change education approach that not only strengthens knowledge but also transforms awareness into sustainable action. Efforts should be made to strengthen attitudes during learning through effective approaches such as field investigations or discussions on socio-cultural values that support sustainability.

Knowledge about climate change must be considered to provide an understanding of all its components, including natural science, social science, political science, and economics. The development of climate change teaching materials must encompass all these components and relate them to students' lives to foster positive attitudes that can encourage climate change mitigation and adaptation behavior. Understanding climate change as intimately connected and relevant to all aspects of life will also encourage multiplicative action within the community and family.

For stakeholders, the findings of this study can be used as input in developing strategic guidelines for climate change education to bridge the gap between knowledge and attitudes and behavior in society. It's time to incorporate climate change into the curriculum, combining cognitive and affective aspects that will strengthen attitudes and encourage the transition from knowledge to behavior. This is especially important in vocational high school curricula, which synchronize the school curriculum with the needs of the business and industrial world. The currently promoted green industry requires vocational high school graduates with knowledge and positive attitudes toward the program.

This study measured climate literacy and climate change awareness among tenth-grade students at vocational high schools in Sumedang Regency. Further research is warranted with more diverse groups, such as comparing tenth-grade students with those in higher grades, or comparing vocational high school students with those in senior high schools. Research comparing students on Java with students outside Java would also provide valuable input for developing climate change education based on local conditions. Research applying technology, such as the development of climate simulation tools, could also be conducted to strengthen strategies for building an Indonesian society capable of facing and adapting to climate change.

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Ethics Statement

The manuscript entitled: "Assessments of Climate Literacy and Climate Change Awareness" is original work, free from plagiarism, fabrication, and copyright infringement. This manuscript has not been previously published and is not currently under review in any other journal. I take full responsibility for the entire contents of the manuscript and agree to its publication in the Jurnal Presipitasi: Media Komunikasi dan Pengembangan Teknik Lingkungan.

Author Membership Credits

Cincin Cintami: conceptualization, methodology, writing-original draft & editing. **Indriyani Rachman**: conceptualization research, validation, format analysis, writing-review & editing. **Anna Permanasari**: validation, writing-review & editing. **Toru Matsumoto**: conceptual reserach, supervision, final chek.

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