International Journal of Evaluation and Research in Education (IJERE)
Vol. 14, No. 5, October 2025, pp. 3650~3664
ISSN: 2252-8822, DOI: 10.11591/ijere.v14i5.33760

Climate science literacy evaluation of senior high school students: a platform for science curriculum enhancement

Hazel R. Balan[1,2], Minie L. Bulay[3], Nelia S. Raganas[3]
[1]College of Education, Caraga State University, Butuan City, Philippines
[2]Department of Education, Gingoog City Comprehensive National High School, Gingoog City, Philippines
[3]Faculty of College of Education, Caraga State University, Butuan City, Philippines

Article Info

Article history:

Received Nov 23, 2024
Revised May 23, 2025
Accepted Jun 12, 2025

Keywords:

Academic track
Climate science literacy
Scientific attitudes
Scientific competence
Scientific knowledge
Technical-vocational-livelihood track

ABSTRACT

The national achievement test results for grade 12 in Gingoog City Division revealed low science proficiency in critical thinking, information literacy, and problem-solving. This study evaluated science literacy related to climate science among senior high school students, focusing on scientific knowledge, competence, and attitudes as a platform for science curriculum enhancement. A descriptive-comparative design was utilized, involving 339 students from randomly selected public secondary schools, determined through stratified sampling using Slovin's formula with a .05 margin of error. Three instruments were modified for the study and validated by experts: a 30-item multiple-choice test for scientific knowledge, a 10-item Likert scale for scientific competence, and a 20-item for scientific attitudes. A pilot test with 30 non-participants yielded a Cronbach's alpha of .76, indicating acceptable reliability. Data analysis involved descriptive and inferential statistics. Results revealed that students in both academic and technical-vocational-livelihood (TVL) tracks generally exhibited low proficiency in scientific knowledge regarding climate change but high scientific competence and attitudes. Significant differences between academic and TVL students in scientific knowledge, competence, and affective engagement were noted. The study concluded that there is a need to improve educational strategies to address learning gaps. Curriculum enhancements should strengthen scientific understanding by integrating climate science topics and developing learning resources and activities.

Corresponding Author:

Hazel R. Balan
College of Education, Caraga State University
Ampayon, Butuan City, Agusan del Norte, Philippines
Email: hazel.balan1976@deped.gov.ph

1. INTRODUCTION

Fostering scientific literacy is a key theme in advancing science education worldwide in the 21st century [1]. One crucial component of science literacy is climate science literacy, which involves recognizing how one's actions can influence and affect overall climate conditions, and how these conditions, in turn, impact each person, and society. The 2025 Science Literacy Framework, outlined in the Program for International Student Assessment (PISA), presents dimensions of climate science literacy, including scientific knowledge, competence, and attitude [2]. Climate change literacy provides students with an understanding of scientific knowledge and principles related to climate change, while empowering them with the skills, attitudes, and values necessary to take action and make a positive impact on the issue [3]. Scientific knowledge encompasses the fundamental concepts of climate change, including its causes, effects, and

mitigating factors. Scientific competence measures students' ability to articulate the scientific reasons behind various occurrences. Students' scientific attitudes reflect their affective engagement, which refers to their emotional responses to certain statements or events related to climate change, and their behavioral engagement, which refers to their active participation in learning activities, actions, and interactions focused on addressing and adapting to climate change issues. Understanding mitigation strategies and adaptation methods is crucial for effectively addressing and adjusting to the challenges caused by climate change, so individuals and organizational sectors can make well-informed and wise decisions [4].

The K-12 science program in the Philippines is designed to provide students with valuable scientific knowledge, abilities, and attitudes relevant to their careers and society. High school is a pivotal time for students to build a solid foundation in scientific concepts and principles. It aims to develop individuals who are scientifically knowledgeable, technologically savvy, and environmentally conscious, capable of addressing the complex challenges of the future. It endeavors to create graduates who can think critically, solve problems effectively, care for the environment, be creative and innovative, make well-informed decisions, and communicate their ideas, as cited by Farillon [5]. Shaping the curriculum around situations and issues that challenge and stimulate learners' curiosity motivates them to engage with and appreciate science as relevant and valuable.

Education is one of the sectors vulnerable to the consequences of climate change. There is substantial evidence that climate change negatively affects educational institutions and students' academic performance [6]. Furthermore, the issue of climate change has significantly affected students' lives and educational experiences. It has been demonstrated that the effects of climate change disproportionately affect the most vulnerable populations, with children among those most at risk of poverty and social exclusion [7]. It has led to an increase in the number of students experiencing hunger, malnutrition, and the worsening of pre-existing health conditions. In addition, there is a chance of a higher dropout rate and a greater risk of domestic abuse for children who are unable to attend due to climate change-related issues.

The Philippines is reported to be one of the country's most at risk from climate change globally, as it is an island nation highly susceptible to extreme weather events [8]. The country is considered one of the most affected by extreme weather, ranking 17th in the world according to the 2021 Global Climate Risk Index. Previous researchers [9], [10] stated that Filipinos' primary concern is the impact of extreme weather conditions caused by climate change. Moreover, 69.5% of Filipinos believed climate change seriously threatens the nation.

Despite the vast sources and availability of information concerning climate change, educators are confronted with various challenges in their teaching endeavors, and finding the most efficient teaching methods still needs to be solved. Even with the urgency of this global issue and ongoing mitigation initiatives, several studies have shown that many students have a poor understanding of the causes, effects, and mitigation of climate change, as well as a low level of climate change awareness, and inconsistent understanding [11]–[16] and lack of efforts, insufficient mitigation responses, behavioral aspects, and commitment in addressing global warming and environmental issues [17], [18]. In an interview, former secretary of Education Leonor Briones of the Philippines emphasized the importance of revising and reassessing the education curriculum. Curricular revision aims to enhance students' and educators' understanding of the outcomes and "evolving issues" related to alterations in Earth's atmospheric and environmental conditions [19].

In the Gingoog City Division, grade 12 students' performance on the national achievement test demonstrated low proficiency in science, particularly in critical thinking, information literacy, and problem-solving. The mean percentage scores (MPS), were below the 50% proficiency level, indicating that students still need to achieve skills in problem-solving, information management, and data analysis and evaluation to understand concepts. Hence, the preceding statements prompted the researcher to investigate students' scientific literacy related to climate science and identify gaps in knowledge as a platform for enhancing the science curriculum to improve students' knowledge, skills, and attitudes to address and mitigate the effects of climate change. Specifically, it addressed the following questions:

i) What is the students' proficiency level in their scientific knowledge of the basic concepts, causes, effects, and mitigation of climate change?
ii) What is the level of students' scientific competence regarding climate change?
iii) What is the level of manifestation of students' scientific attitude on climate change in terms of affective engagement?
iv) What is the level of manifestation of students' scientific attitude on climate change in terms of behavioral engagement?
v) Is there a significant difference in the levels of scientific knowledge, scientific competence, and scientific attitudes regarding affective engagement between students in the academic track and those in the TVL track?

vi) Based on the findings of the study, what enhancements to the science curriculum can be proposed to integrate climate change adaptation and mitigation?

The academic and technical-vocational-livelihood (TVL) tracks are among the offerings of the senior high school program under the K to 12 curriculums. The academic track program helps students prepare for the subject specializations of their upcoming college courses, while the TVL track is intended to support students in acquiring the necessary skills and knowledge for domestic and international employment opportunities. They may have different educational focuses and goals, approaches, and types of skills and knowledge acquired. This study investigates how their learning experiences, both in classroom instruction and through interactions with real-life situations, have potentially influenced them as depicted in their understanding, motivation, and engagement in alleviating the effects of climate change.

The study is anchored on Jean Piaget's constructivist theory, which suggests that learners actively create their understanding by reflecting on their experiences, constructing mental frameworks, and integrating new knowledge into existing mental models [20]. A more comprehensive interpretation of learners' knowledge and skills concerning climate change can be determined by evaluating them in both formal academic (academic track) and real-world, hands-on settings (TVL track). Understanding how these differences impact climate science literacy can help teachers tailor educational approaches and activities that fit the needs of students in various learning tracks, which is crucial for encouraging sustainable practices and addressing environmental challenges.

Evaluating students' comprehension of climate science is both timely and critical, given the urgency of the global climate crisis. This study offers a novel contribution by explicitly assessing climate science literacy among senior high school students in the Philippines, specifically comparing those in the academic and TVL tracks. Its comparative approach reveals how differences in curriculum design influence students' scientific understanding, offering a new perspective on tailoring climate education to diverse learning pathways. By leveraging localized data, the study proposes an evidence-based framework with targeted indicators to strengthen science curricula by embedding climate adaptation and mitigation strategies. Aligned with the Philippine K–12 system and national environmental policies, this research supports the development of context-specific strategies to strengthen ecological awareness and promote more effective climate action among future generations.

2. METHOD

2.1. Research design

A quantitative research design employing descriptive-comparative analysis was used to assess and compare the climate science literacy levels of senior high school students across different tracks, specifically the academic and TVL tracks. This quantitative research aimed to gather quantifiable data for statistical analysis of the population sample [21]. It involved characterizing the features or phenomena of the subjects and describing the differences between groups within the population under investigation [22]. This research design systematically measures and describes key variables such as students' scientific knowledge, skills, and attitudes related to climate change, allowing for statistical comparisons between groups. The goal was to identify significant differences or similarities in literacy levels, providing insights to inform curriculum improvements and targeted interventions that enhance students' understanding and engagement with climate science.

2.2. Research locale and participants of the study

The Gingoog City Division comprises ten districts of public secondary schools, from which one secondary school was randomly selected in each district. The overall participant count for the study was calculated using Slovin's formula with a margin of error of .05. A stratified sampling design was used to determine the number of students from each school, resulting in a total of 339 participants in the study.

2.3. Research instruments, validation, and procedure

Three instruments were adapted and modified by the researcher, then validated by experts in the field. A panel of professionals, including a science education program specialist, the science department head, a science master teacher, a university science professor, and an expert in measurement and evaluation, conducted the expert validation of the instruments. The validation team was tasked with evaluating the suitability of the questionnaire using an expert judgment form. The comments, suggestions, and feedback received during the validation process were incorporated to improve the research instruments. Adapting these research instruments was crucial to fit the specific educational environment of Gingoog City, as they reflected cultural relevance, local experiences, and contexts imperative for enhancing academic outcomes and fostering climate-resilient mindsets and practices among students. This adaptation played a significant role in

supporting community sustainability efforts, especially in light of the climate-related challenges that Gingoog City has been facing, such as extreme temperatures, floods, and landslides.

A 30-item multiple-choice test questionnaire was used to assess students' scientific knowledge regarding climate change adaptation and mitigation. The questionnaire underwent item analysis, and the test scores were transmuted to grades based on DepEd Order No. 8, s. 2015. Scientific competence was evaluated using a 10-item, five-point Likert scale adapted and modified from OECD/PISA [23], as well as Azevedo and Marques [24]. The 20-item five-point Likert scale, which determined the students' scientific attitudes regarding affective and behavioral engagement relative to climate change adaptation and mitigation, was adapted from Chairunnisa *et al.* [25] and Tse [26] and modified for the study. The scoring and quantification of the data are presented in Table 1 for scientific knowledge and in Table 2 for scientific competence and attitudes.

The research instruments underwent a pilot test involving 30 non-participants. Cronbach's alpha was calculated, yielding a value of .76, which indicates acceptable consistency and reliability. A few adjustments were then made to refine and finalize the instruments. The researcher sought approval by writing letters to the school division superintendent, district supervisors, and school principals to officially conduct the study. Before distributing the survey questionnaires, the researcher provided information about the nature and purpose of the research and explained that all information and participant identities would be kept confidential. Ethical considerations were carefully observed in this study. The researcher ensured that the participants were not harmed in any way and obtained their full consent. Participants completed an informed consent form, and parental consent was obtained for those under 18 years old.

Table 1. Transmutation of test scores in terms of scientific knowledge

Score	Transmuted grade	Description
28-30	90 and above	Outstanding
25-27	85-89	Very satisfactory
22-24	80-84	Satisfactory
18-21	75-79	Fairly satisfactory
17 and below	74 and below	Did not meet expectations

Table 2. Levels of scientific competence and attitude based on affective and behavioral engagement

Scale	Mean range	Descriptive rating	Interpretation
5	4.50-5.00	Strongly agree	Very high
4	3.50-4.49	Agree	High
3	2.50-3.49	Undecided	Moderate
2	1.50-2.49	Disagree	Low
1	1.00-1.49	Strongly disagree	Very low

2.4. Data analysis

The study employed descriptive and inferential statistical methods. Frequency and percentage were used to describe the profiles of the respondents. The weighted mean measured senior high school students' scientific competence and attitudes on climate change adaptation and mitigation. Additionally, a t-test was conducted to examine whether significant differences existed in knowledge, competence, and attitudes toward climate change adaptation between students in the academic track and those in the TVL track.

3. RESULTS AND DISCUSSION

The climate science literacy evaluation of senior high school students in the Gingoog City Division was conducted with 339 participants. The academic track comprised 58% of the participants, while the TVL track comprised 42%, with 197 and 142 students, respectively.

3.1. Students' proficiency level of scientific knowledge on climate change

Table 3 presents the students' proficiency levels in scientific knowledge of the basic concepts, causes, effects, and mitigation of climate change. About 55% of students in the academic track and 86% in the TVL track obtained a grade of 74 or below, indicating that students at this level have difficulty understanding and that foundational knowledge and skills must be developed to support their comprehension and learning. About 23% of students in the academic track and 13% in the TVL track obtained a grade of 75–79, rated as "fairly satisfactory." This suggests that students at this level possess the minimum required knowledge, skills, and core understanding, but still need support throughout the learning process. At the same time, 14% of students in the academic track and only 1% in the TVL track achieved a satisfactory proficiency

level. At this level, students have acquired the essential knowledge, skills, and core understanding of climate change but still require some guidance and support from teachers and peers. About 7% of the students on the Academic track have attained a very satisfactory level, indicating that they have acquired the required core understanding, skills, and knowledge and can apply them independently through real-world tasks.

Table 3. Proficiency level of scientific knowledge of students on the basic concepts, causes, effects, and mitigation of climate change

Score ranges	Academic track		TVL track		Total		Transmuted grade	Descriptive rating
	f	%	f	%	f	%		
28-30	1	.50	0	0	1	.3	90 and above	Outstanding
25-27	14	7.10	0	0	14	4.1	85-89	Very satisfactory
22-24	27	13.71	2	1.4	29	8.6	80-84	Satisfactory
18-21	46	23.35	18	12.7	64	18.9	75-79	Fairly satisfactory
17 and below	109	55.33	122	85.9	231	68.1	74 and below	Did not meet expectations
Total	197	100	142	100	339	100		

Only one student in the academic track obtained a grade of 90, demonstrating an outstanding proficiency level and showing remarkable mastery and understanding of the basic concepts of climate change. However, in the TVL track, no student achieved a grade of 85 or above, indicating that none demonstrated satisfactory or outstanding proficiency. The lack of core understanding, skills, and knowledge about climate change among TVL students suggests that their training and exposure have focused more on technical skills than on theoretical knowledge, potentially leaving them without a solid foundation. These challenges are similar to those reported in the study by Luisen [27], where TVL students at a Philippine university struggled to express and generate ideas.

Overall, results revealed that 68% of the students across both tracks scored very low, with proficiency below 75%, indicating they did not meet expectations. These findings imply significant gaps in knowledge and awareness of this pressing global issue, regardless of whether students are pursuing academic studies or enrolled in TVL tracks. There may be insufficient integration of climate science into diverse disciplines, and the education system may not adequately address climate change in its curriculum due to limited resources and a lack of emphasis on environmental education. This result is supported by Ma and Chen [28], who state that many national curricula either lack references to climate change or address it superficially. It is not adequately equipping our youth with the essential knowledge and skills they need to address this critical issue. The authors argue for the incorporation of climate education into formal curricula to develop resilience and awareness among youth in these regions. This aligns with the findings of Baldwin *et al.* [29], who surveyed 425 secondary school students to assess the causes, impacts, and mitigation strategies of climate change. Though students reported awareness of climate change impacts, significant knowledge gaps existed regarding effective mitigation measures. Many also expressed low self-efficacy and hope concerning climate action, highlighting the need for educational interventions to empower youth.

The finding corroborates earlier research in Philippines, where a considerable number of grade 12 senior-high-school students still exhibited inadequate knowledge regarding the causes, impacts, and solutions to climate change [11]. This poor understanding and awareness of climate science is further evidenced by the consistently low performance of Filipino students in international science literacy assessments, as demonstrated in the PISA 2018, where the country's average science literacy scores ranked second to last among 78 countries [30]. This condition indicates a need for immediate targeted interventions and reforms in climate science education to enhance scientific literacy among Filipino students. A comprehensive climate change literacy program is essential and can be implemented by integrating climate lessons into various subjects, equipping teachers with proper training and updated resources, and developing a curriculum-aligned learning plan to enhance students' knowledge, perceptions, and attitudes toward climate change [31].

3.2. Students' level of scientific competence on climate change

The findings from the investigation into students' scientific competence regarding climate change are presented in Table 4. Results revealed that the students agree that they have a high level of scientific competence to decide responsibly and with knowledge regarding actions that have some effects on climate and the environment, with the highest weighted mean value of 4.10. This result could be due to the exposure and experience of students with real-world scenarios and phenomena, as well as educational interventions. Evidence of this includes the actual experiences and observations of students participating in school conservation initiatives and practicing mindful energy consumption in the classroom. This idea aligns with the study by Kurup *et al.* [32], which highlights that with appropriate interventions, students gain a deeper

understanding of the causes and consequences of global warming. This enables them to apply their knowledge in making informed decisions about climate change, indicating that they are now better equipped to take responsible action in the future. By teaching science in a way that encourages informed decision-making, students are empowered to take proactive steps to address this critical issue. It was closely followed by the ability to discuss how human actions or activities contribute to climate change, communicate about climate and climate change meaningfully, design scientific inquiry or questions, and solve problems by considering alternative possible solutions with weighted mean values of 4.03, 3.99, and 3.88, respectively.

Table 4. Level of scientific competence of the students on climate change

	Indicators	Wtd mean	SD	Verbal description	Interpretation
1.	Explain how carbon dioxide emissions affect global climate change.	3.76	1.029	Agree	High
2.	Discuss how human activities contribute to climate change.	4.03	.992	Agree	High
3.	Apply appropriate scientific knowledge to explain certain phenomena.	3.80	.954	Agree	High
4.	Discuss the consequences of economic development on the environment.	3.86	.979	Agree	High
5.	Explain why some countries suffer more from global climate change than others.	3.84	.952	Agree	High
6.	Assess scientifically credible information about climate change.	3.83	.991	Agree	High
7.	Interpret data and evidence before making critical decisions.	3.85	1.015	Agree	High
8.	Communicate about climate and climate change in a meaningful way.	3.99	.996	Agree	High
9.	Make informed and responsible decisions regarding actions that may affect climate and the environment.	4.10	.991	Agree	High
10.	Design scientific inquiry or questions and solve problems by considering alternative possible solutions.	3.88	1.031	Agree	High
	Overall weighted mean	3.89	.730	Agree	High

Legend: 1.00-1.49=strongly disagree/very low; 1.50-2.49=disagree/low; 2.50-3.49=undecided/moderate; 3.50-4.49=agree/high, 4.50-5.00=strongly agree/very high.

The overall weighted mean is 3.89, with a verbal description of "agree," which indicates a high level of scientific competence. It shows the students' capability to articulate scientifically the reasons behind various occurrences through the recall and application of relevant scientific knowledge and the ability to address problems by considering various alternative solutions. It could be attributed to students' exposure to various resources, news, articles, documentaries, online materials, and worldwide disasters and calamities. This result aligns with the study by Esakkimuthu and Banupriya [33], which identifies formal education, social media platforms, and environmental advocacy groups as primary sources of information for students on ecological issues.

Some students are also genuinely interested in climate change, leading them to seek more information and engage more deeply with the topic or work together on projects or assignments related to climate change, fostering a cooperative educational setting where they can get knowledge from one another and build upon each other's knowledge and skills. It suggests that students become more informed, involved, capable of making knowledgeable decisions, and eager to support initiatives to combat climate change and encourage a more efficient, environmentally friendly future. Evidence of this can be observed in classroom activities, including initiatives and advocacy efforts aimed at creating awareness campaigns. These initiatives include establishing signage and posters on energy conservation and designing science investigatory projects that focus on creating gadgets, innovations, machines, and even robots to address environmental problems. Examples include filtering devices for water purification, electrical devices for energy generation, and exhaust filters for vehicles to reduce carbon dioxide emissions. This implies that students demonstrated skills and competence in designing scientific inquiries or questions to solve problems.

These ideas correspond to the report of Luqman [34] that younger generations, specifically Gen Z and millennials, are particularly notable for their strong interest and involvement in addressing climate change. It reveals that millennials actively pursue climate-related information through various channels, reflecting their concern and proactive stance on environmental issues. They are more likely to discuss the importance of acting on climate change, consume more climate-related content online, and participate in related activities such as volunteering to promote climate activism, making them prominent voices in global conversations on climate action. In addition, a study pointed out that respondents at a State University in Region III, Philippines, were aware of some sources of climate change, such as greenhouse gas emissions (87.12%), deforestation (57.58%), and excessive fertilizer use (37.88%), but were unaware of other causes [13]. While students' high competence regarding climate change is promising, it must be consistently fostered and developed through efficient teaching strategies and materials. By doing so, students will be ready to address the future challenges climate change presents, ensuring their continued readiness to manage its complexities.

3.3. Students' level of manifestation of the scientific attitude on climate change in terms of affective engagement

Table 5 shows the data regarding the level of manifestation of students' scientific attitudes toward climate change in terms of affective engagement. Results revealed that most students exhibit a high level of affective engagement, which made them feel worried that the future generation might not be able to experience the beauty of the present nature/environment, with the highest weighted mean value of 4.22. This worry may come from the thought that climate change will harm their own lives and the lives of future generations, making them worse off than they are today. Similarly, news reports about climate-related disasters on television and other media platforms may elicit deep and heightened emotional responses. This conception conforms to the research surveyed by Hickman *et al.* [35], which surveyed 10,000 individuals aged 16–25 across ten countries, including the Philippines, where 59% of respondents described themselves as "very" or "extremely" worried about the effects of climate change. Many participants also reported experiencing emotions such as sadness, anxiety, anger, a sense of powerlessness, helplessness, and guilt.

Table 5. Level of manifestation of students' scientific attitude on climate change in terms of affective engagement

Indicators	Wtd mean	SD	Verbal description	Interpretation
1. Concerned/alarmed about the effects of climate change in the world.	4.21	.902	Agree	High
2. Worried that the future generation might not be able to experience the beauty of the present nature/environment.	4.22	1.025	Agree	High
3. Convinced that global warming is happening.	3.99	1.023	Agree	High
4. Paid special attention to climate change news and articles.	3.81	.960	Agree	High
5. Believed that I know a lot about climate change.	3.66	.890	Agree	High
6. Believed that human activities are the primary cause of the climate change problem.	4.11	.979	Agree	High
7. Saddened that the problem of climate change is too serious, and our actions are already too late.	3.92	1.013	Agree	High
8. Believed that people should lessen their energy consumption to reduce the adverse effects of climate change.	3.96	.984	Agree	High
9. Believed that all of us can do many things to alleviate or reduce the climate change problem.	4.20	.957	Agree	High
10. Adapted to different situations and changes even when under stress and pressure.	3.82	.951	Agree	High
Overall weighted mean	3.99	.686	Agree	High

Legend: 1.00-1.49=strongly disagree/very low; 1.50-2.49=disagree/low; 2.50-3.49=undecided/moderate; 3.50-4.49=agree/high; 4.50-5.00=strongly agree/very high.

They are also concerned and alarmed about the global effects of climate change and believe that individuals can take numerous actions to mitigate or lessen the issue, with weighted mean values of 4.21 and 4.20, respectively. This result aligns with the survey, which revealed that nearly half (45%) reported their concerns about climate change adversely impacting their daily life and functioning [35], and that they believe the world will become darker and scarier, with a frightening future [36]. The overall weighted mean is 3.99, with a verbal description of "agree", indicating that most students have a high emotional involvement regarding climate change, as reflected in their scientific attitudes. These results imply that students find the issue extremely alarming and care deeply about it. Strong emotional connections can lead to increased affective domain of learning, enhance motivation to learn about these global issues, engage in discussions, provide them with the skills and knowledge needed to influence others, and potentially contribute to finding solutions to the problem. It may lead to favorable attitudes that connect what they have learned to what they can do [7], [37], [38].

Based on the actual classroom observation, the opinions expressed by students during class discussions demonstrated how articulate and deeply engaged they are in addressing their concerns about climate change. This was particularly evident when they shared their personal experiences during disasters and strongly supported those affected by natural calamities. These positive responses reflect significant and promising outcomes in both academic and societal contexts, as emotions play a significant role in shaping social reactions to climate change, affecting how information is obtained, comprehended, and disseminated.

This finding aligns with the conclusions drawn by Jones and Lucas [39], where a recent survey of 1,943 Australian youth aged 15-19 revealed that they are deeply concerned about climate change, often feeling anxious, helpless, and frustrated. When sharing these concerns, they trust their friends the most, followed by parents and teachers. Desabayla and Gueta [9] referenced Valmonte's report in 2022, which cited the 2021 world risk poll conducted by the Lloyd Register Foundation. According to the poll, a large

portion of the Filipino population expressed deep concern over the damaging effects of extreme weather linked to climate change, with 69.5% acknowledging it as a major threat to the country.

Moreover, students also have a high level of engagement in giving special attention to climate change news and articles, which relates to the study of Sanchez *et al.* [40] involving undergraduate students from a higher education institution in Davao City, Philippines. The study identified that media influence, news, and the internet as significant contributors to students' awareness. While students' high competence regarding climate change is promising, it must be consistently fostered and developed through efficient teaching strategies and materials.

3.4. Students' level of manifestation of the scientific attitude on climate change in terms of behavioral engagement

Table 6 shows the results of the level of students' scientific attitude manifestation concerning behavioral involvement in climate change. Results revealed that the students strongly agree they exhibit a very high level of scientific attitude in terms of behavioral engagement, particularly in turning off the lights when leaving the room, as indicated by the highest weighted mean value of 4.51. They tend to turn off the lights when not in use, which is the most observable action they can take, likely because it has been instilled in them at home and school and has become part of their routine. The study suggests that being taught to turn off lights is a critical factor in why this habit remains prevalent. This outcome runs like the study of Lundberg *et al.* [41], where the research found that 36.3% of respondents, when asked about the most effective way to save energy, is to turn off the lights.

Table 6. Level of manifestation of students' scientific attitude on climate change in terms of behavioral engagement

Indicators	Wtd mean	SD	Verbal description	Interpretation
1. Walk for short distances.	3.69	1.030	Agree	High
2. Take public transportation or ride a bike instead of using a personal car.	3.31	1.395	Undecided	Moderate
3. Turn off the lights when leaving the room.	4.51	.861	Strongly agree	Very high
4. Lessen the use of electrical appliances if possible.	3.94	1.036	Agree	High
5. Set a timer when using the air-conditioner and refrigerator to minimize time usage.	3.31	1.338	Undecided	Moderate
6. Use organic-based sprays in repelling insects and other plant-based materials.	3.33	1.255	Undecided	Moderate
7. Use both sides of the paper when drawing or writing.	3.78	1.088	Agree	High
8. Separate waste materials for recycling and decompose waste instead of burning.	4.16	.981	Agree	High
9. Participate in tree planting, backyard gardening, and cleaning programs at home, school, and the community.	4.18	.948	Agree	High
10. Donate items like food, clothes, and other important items to people in need and during disasters and accidents.	3.60	1.160	Agree	High
Overall weighted mean	3.78	.632	Agree	High

Legend: 1.00-1.49=strongly disagree/very low; 1.50-2.49=disagree/low; 2.50-3.49=undecided/moderate; 3.50-4.49=agree/high; 4.50-5.00=strongly agree/very high.

Furthermore, students also agree that they are highly engaged in participating in tree planting, backyard gardening, and cleaning programs at home, school, and community, separate waste materials for recycling and decomposing waste instead of burning, and lessen the use of electrical appliances, if possible, with mean values of 4.18, 4.16, and 3.94, respectively. Students are deeply engaged in these activities because they are common and practical exercises conducted in most schools that provide hands-on experience, such as tree planting, community cleaning initiatives, and school gardening projects like "Gulayan sa Paaralan." By consistently practicing these habits at school and potentially adopting them at home, students develop a sense of responsibility and make eco-friendly actions a part of their daily routine. Students further agree that they are highly engaged in walking short distances and utilizing both sides of paper when drawing or writing and donating items like food, clothes, and other important things to people in need during disasters and accidents. These results are aligned with the findings of some surveys stating that taking zero-emission modes like the individual's intrinsic preference for walking [42], biking and paper recycling [43], and engaging society in emergency services providing food, supplies, and money, shelter or offering medical and psychological aid [44] is one of the sustainable practices of mitigation.

The overall weighted mean is 3.78 with a verbal description of "agree," which means a very high level of manifestation of scientific attitude in behavioral engagement. This outcome suggests that students will likely take the initiative to reduce their environmental impact, participate in climate change mitigation efforts, and adapt to its effects, making them less vulnerable to its negative consequences. As per observation in most schools, students diligently observe proper waste segregation and disposal since the hygienic

coordinator monitors this daily to ensure the implementation of the said activity. Students' responsible use of electrical devices is commendable in almost all schools. The school has established specific hours during which electricity can be used. This measure effectively conserves energy, reduces costs, and promotes environmental responsibility. Students are actively engaged in environment-related activities at school in compliance with DepEd Order No. 33, s. 2008. These actions address the risks and challenges of climate change and global warming, as they are mandated and strictly implemented in schools.

The result coincides with the findings of Kolenatý *et al.* [45], who pointed out in the interviews with focus groups in several schools in the Czech Republic that the enhanced readiness often translated into real climate action and reduction of carbon footprint demonstrated to be an extremely convenient and practical way to the involvement of participants in individual climate action. Similarly, students' knowledge and attitudes towards global warming were investigated at Assiut University, Egypt. According to the study, the outcomes revealed that most participants had a favorable perspective and attitude on the topic [11]. In a study at Rutgers University in New Jersey, paper waste was significantly reduced by making double-sided printing the default setting in computer labs. As a result, the university saw a substantial decrease in paper consumption, translating to a remarkable 7.4 million sheets of paper saved-equivalent to preserving nearly 620 trees. This change also helped minimize the environmental impact of deforestation and paper processing emissions. Most students adapted to the new default setting, leading to a lasting shift towards paper conservation becoming the standard practice [43].

In the Philippines, senior high school students enrolled in the science, technology, engineering, and mathematics (STEM) strand demonstrated a strong positive attitude toward climate change, actively engaged in biodiversity conservation, and showed environmental sustainability awareness and concerns about climate change [46]. It suggests that they tend to express a strong desire to engage in efforts aimed at solving global issues. In addition, a study was conducted in Negros Oriental High School, which aimed to determine the knowledge level and emotional and behavioral reactions of grade 12 students toward climate change. Students displayed "favorable" affective and behavioral responses to actions concerning climate change [7].

A relevant study was conducted in the Philippines that explored students' experiences and perceptions of participating in tree planting activities in San Jose, Batangas [47]. Participants expressed feelings of satisfaction and fulfillment, describing the activity as providing a 'sense of success and service from the heart,' which reflects a deep sense of achievement and a strong commitment to contributing positively to the environment. This activity increased students' awareness of environmental concerns and highlighted the significance of individual endeavors in addressing climate change issues. Additionally, students developed a renewed appreciation for nature and showed a greater interest in participating in future environmental initiatives.

3.5. Test of significant difference in the level of scientific knowledge, competence, and attitude between profile variable groupings

Table 7 shows the t-test result on the students' scientific knowledge, competence, and attitudes on climate change when grouped according to track. The analysis yielded a t-value of 6.251 and a p-value of .000, indicating a very significant difference between the two groups in the proficiency level in scientific knowledge. It also shows a significant disparity between students in the academic track and those in the TVL track regarding scientific competence (t=2.30, p=.018) and scientific attitudes regarding affective engagement (t=2.788; p=.006). Therefore, the null hypothesis related to these variables is rejected.

The results showed that a greater number of students in the academic track have a better understanding and skills on the concepts of climate change than the TVL track, as revealed by higher scores on the test. The significant difference in the knowledge, competence, and affective engagement between the academic and TVL tracks can be attributed to the fact that only two science subjects, earth and life and physical sciences, are taught in the TVL track. While in the academic track, particularly within the STEM strand, there are more specialized subjects such as biology, chemistry, physics, earth science, disaster preparedness, and risk reduction (DRRR), which comprehensively cover concepts related to climate change [48].

Table 7. T-test on the level of scientific knowledge, competence, and attitudes of senior high school students on climate change when grouped according to track

Areas of comparison	t	*p*-value	Decision on H_o	Interpretation
Scientific knowledge	6.251**	.000	Reject H_o	Significant
Scientific competence	2.380*	.018	Reject H_o	Significant
Scientific attitude in terms of affective engagement	2.788**	.006	Reject H_o	Significant
Scientific attitude in terms of behavioral engagement	1.044	.291	Fail to reject H_o	Not significant

** significant at p<.01; * significant at p<.05.

Additionally, the academic track focuses on acquiring knowledge essential for understanding various subjects. Through this approach, students cultivate their critical thinking abilities, learn to tackle complex problems and refine their skills in applying theoretical knowledge to real-world situations. It allows them to explore complex issues like climate change and environmental issues more thoroughly, fostering a more profound understanding of these critical subjects. Meanwhile, the TVL track places greater emphasis on transferable skills that are directly relevant to skill-based learning activities.

This idea is supported by the study of Lagon [49], which found a strong positive correlation between students' general scholastic aptitude and their academic performance, suggesting that those with higher aptitude scores are more likely to choose the STEM strand. Similarly, Nazareno *et al.* [50] also pointed out the association between students' academic performance and their chosen SHS track. Students who achieved higher marks, especially in mathematics and science, showed a preference for the STEM strand. In contrast, students with lower academic results were more likely to choose the general academic strand (GAS) or the TVL track. These findings also align with the idea that knowledge about climate change is a primary motivator for climate action, particularly among young people, which suggests that individuals are more likely to adopt eco-friendly habits when they comprehend the underlying reasons and consequences of climate change [46].

This finding runs like the study of Alkair *et al.* [51], which showcases a STEM-based approach to environmental sustainability education, where students are encouraged to solve real-world problems. The program significantly enhanced students' comprehension of environmental concerns, as reflected in the study's findings. Observations and feedback from students and facilitators revealed that they developed more vital collaborative problem-solving skills, indicating a positive shift in their attitudes toward working together to tackle complex issues.

Additionally, these results align with the study conducted by Almerino *et al.* [52], which evaluated the academic achievement of K-12 students in the Philippines through the scholastic ability test. The findings showed that students in the STEM and accountancy, business, and management (ABM) strands scored above average, whereas those in humanities and social sciences (HUMSS) and GAS generally attained average scores. In contrast, students in the TVL strand tended to perform below average in most subtests.

Further analysis showed that the two groups did not differ significantly in the manifestation of scientific attitudes regarding behavioral engagement, as evidenced by a t-value of 1.044 and a p-value of .291. This data does not refute the null hypothesis. It implies that regardless of the educational program or course in which students are enrolled, they may unknowingly engage in activities that could indirectly contribute to efforts to reduce and adjust to the effects of climate change. This finding may be attributed to the practices integral to daily school and community life. For instance, school observations have shown that students from all year levels and tracks are uniformly expected to separate waste, participate in cleaning and gardening activities, and refrain from burning trash and recycling waste materials. In addition, it was also reported that students in the senior high school program have varying degrees of knowledge concerning climate change issues. However, both cases had a positive outlook on these concerns, indicating they are more inclined to demonstrate readiness for pro-environmental action [47]. It shows that regardless of their existing knowledge level or the track they are enrolled in, students are likely to engage in activities and take favorable actions concerning climate change mitigation and adaptation.

3.6. Proposed curriculum enhancement integrating climate change adaptation and mitigation

Based on the findings of the study, the key indicators for curriculum enhancement aimed at integrating climate change adaptation and mitigation are outlined in Table 8 (see Appendix). The proposed curricular enhancement aims to establish a strong connection between students, teachers, administration, and the community. This approach fosters collaboration and engagement, providing a more comprehensive and well-rounded educational experience.

4. CONCLUSION

The climate science literacy evaluation among senior high school students reveals that most students in both the academic and TVL tracks demonstrate low proficiency in scientific knowledge of the basic concepts, causes, effects, and mitigation of climate change, as indicated by their low test scores. However, students exhibit a high level of scientific competence and scientific attitude toward climate change regarding affective and behavioral engagements. Students show a strong emotional connection to climate change issues, expressing concern and alarm about its global impacts. Behaviorally, students demonstrate proactive engagement in energy conservation and eco-friendly practices, indicating a strong willingness to participate in environmental initiatives aimed at mitigating climate change. Students on the academic track performed better than those on the TVL track in scientific knowledge, scientific competence, and scientific attitudes regarding affective engagement. However, students in the academic and TVL tracks shared similarities in

manifesting scientific attitudes regarding behavioral engagement. The study presents the need to improve educational strategies to address learning gaps in climate science. Curriculum enhancements should focus on scientific understanding by integrating climate science topics and developing tailored learning resources and activities for diverse student needs.

This gap suggests that, although students may demonstrate competence and positive attitudes toward climate change, they often lack the corresponding scientific knowledge. Teachers may need to create focused teaching approaches that link students' skills to a more thorough comprehension of climate science. Educators can cultivate informed, proactive citizens ready to tackle climate challenges by addressing the knowledge gap while capitalizing on students' strengths.

It is strongly recommended that the research findings be disseminated to facilitate the suggested curriculum enhancements in the various learning tracks of senior high school programs. A focal person and a support group may be designated to coordinate climate change education (CCE) and awareness within the school, fostering a comprehensive approach to climate education. Further research should be conducted among junior high school students across various programs to validate the findings of this study and to assess the level of instructional management in subjects where CCE is integrated.

FUNDING INFORMATION

The research were supported entirely by the personal funds of the authors. There were no external funding sources or institutional financial support involved in the completion of this work.

AUTHOR CONTRIBUTIONS STATEMENT

The research presented in this dissertation results from the collaborative efforts and individual contributions of each author.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Hazel R. Balan	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	
Minie L. Bulay		✓	✓	✓	✓			✓		✓	✓	✓	✓	
Nelia S. Raganas	✓	✓	✓	✓	✓			✓		✓	✓	✓	✓	

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

We declare that there are no conflicts of interest associated with the research presented in this dissertation. Throughout the research process, we ensured that all data, findings, and interpretations were the result of our independent work, free from any external influences that could compromise the objectivity of our research. We did not receive any funding, support, or assistance from organizations or individuals who might have a vested interest in the outcomes of this work.

DATA AVAILABILITY

The datasets generated and analyzed are available upon reasonable request. Interested researchers may obtain access to the data by contacting the corresponding author [HRB], to facilitate further research or verification. Requests for data should be directed via email at hazel.balan1976@deped.gov.ph.

REFERENCES

[1] P. Xinning and Z. Tainian, "Comparative study on development of science education worldwide: advance in ideas, themes and practice," *Bulletin of Chinese Academy of Sciences*, vol. 7, no. 7, pp. 771–778, 2021, doi: 10.16418/j.issn.1000-3045.20210517001.

[2] OECD, *PISA 2015 Assessment and Analytical Framework: Science, Reading, Mathematic and Financial Literacy*. Paris: OECD Publishing, 2016, doi: 10.1787/9789264255425-en.

[3] J. D. Johnston, "Climate change literacy to combat climate change and its impacts," in *Climate Action. Encyclopedia of the UN Sustainable Development Goals*, W. L. Filho, A. M. Azul, L. Brandli, P. G. Özuyar, and T. Wall, Eds., Springer, Cham, 2020, pp. 200–212, doi: 10.1007/978-3-319-95885-9_31.

[4] I. Ratinen, "Students' knowledge of climate change, mitigation and adaptation in the context of constructive hope," *Education Sciences*, vol. 11, no. 3, p. 103, 2021, doi: 10.3390/educsci11030103.
[5] L. M. F. Farillon, "Scientific Reasoning, Critical Thinking, and Academic Performance in Science of Selected Filipino Senior High School Students," *Utamax: Journal of Ultimate Research and Trends in Education*, vol. 4, no. 1, pp. 50–62, 2022, doi: 10.31849/utamax.v4i1.8284.
[6] M. Hussain *et al.*, "A comprehensive review of climate change impacts, adaptation, and mitigation on environmental and natural calamities in Pakistan," *Environmental Monitoring and Assessment*, vol. 192, no. 1, p. 48, Jan. 2020, doi: 10.1007/s10661-019-7956-4.
[7] W. L. Filho, M. Balasubramanian, R. A. A. Zuñiga, and J. Sierra, "The effects of climate change on children's education attainment," *Sustainability*, vol. 15, no. 7, p. 6320, Apr. 2023, doi: 10.3390/su15076320.
[8] W. N. Holden and S. J. Marshall, "Climate change and typhoons in the Philippines: extreme weather events in the Anthropocene," in *Integrating Disaster Science and Management*, P. Samui, D. Kim, and C. Ghosh, Eds., Amsterdam: Elsevier, 2018, pp. 407–421, doi: 10.1016/B978-0-12-812056-9.00024-5.
[9] R. R. Desabayla and N. G. Gueta, "The climate change awareness among senior high school students in Sorsogon province, Philippines," *European Journal of Theoretical and Applied Sciences*, vol. 1, no. 2, pp. 84–92, Apr. 2023, doi: 10.59324/ejtas.2023.1(2).09.
[10] V. Bollettino, T. Alcayna-Stevens, M. Sharma, P. Dy, P. Pham, and P. Vinck, "Public perception of climate change and disaster preparedness: evidence from the Philippines," *Climate Risk Management*, vol. 30, p. 100250, 2020, doi: 10.1016/j.crm.2020.100250.
[11] M. M. Akrofi, S. H. Antwi, and J. R. Gumbo, "Students in climate action: A study of some influential factors and implications of knowledge gaps in Africa," *Environments*, vol. 6, no. 2, p. 12, Jan. 2019, doi: 10.3390/environments6020012.
[12] Sulistyawati, S. A. Mulasari, and T. W. Sukesi, "Assessment of knowledge regarding climate change and health among adolescents in Yogyakarta, Indonesia," *Journal of Environmental and Public Health*, vol. 2018, no. 1, p. 9716831, 2018, doi: 10.1155/2018/9716831.
[13] B. Y. Ofori, E. P. K. Ameade, F. Ohemeng, Y. Musah, J. K. Quartey, and E. H. Owusu, "Climate change knowledge, attitude and perception of undergraduate students in ghana," *PLOS Climate*, vol. 2, no. 6, Jun. 2023, doi: 10.1371/journal.pclm.0000215.
[14] N. Salman, M. Al-Mannai, A. Abahussain, and M. S. M. Alalawi, "Young students' knowledge, attitude and practice towards climate change," in *Global Warming: A Concerning Component of Climate Change*, V. Kumar, Ed., London: IntechOpen, 2023, doi: 10.5772/intechopen.1002528.
[15] A. A. Ibrahim, H. D. Fahmy, and S. R. Mahmoud, "Knowledge and attitude regarding global warming phenomenon among Assiut University Students," *Assiut Scientific Nursing Journal*, vol. 6, no. 14, pp. 1–11, Aug. 2018, doi: 10.21608/asnj.2018.58596.
[16] M. Ünal, "The Climate Literacy Levels of Secondary School Students and Their Opinions on Climate Change," *Bartın Üniversitesi Eğitim Fakültesi Dergisi*, vol. 12, no. 4, pp. 673–690, Oct. 2023, doi: 10.14686/buefad.1346851.
[17] A. M. Corpuz, "Knowledge and adaptation practices: baseline data for the development of climate change engagement model," *International Journal of Multidisciplinary: Applied Business and Education Research*, vol. 4, no. 6, pp. 1920–1931, Jun. 2023, doi: 10.11594/ijmaber.04.06.18.
[18] A. E. Piggott-McKellar, K. E. McNamara, P. D. Nunn, and J. E. M. Watson, "What are the barriers to successful community-based climate change adaptation? A review of grey literature," *Local Environment*, vol. 24, no. 4, pp. 374–390, Apr. 2019, doi: 10.1080/13549839.2019.1580688.
[19] V. Winter, J. Kranz, and A. Möller, "Climate Change Education Challenges from Two Different Perspectives of Change Agents: Perceptions of School Students and Pre-Service Teachers," *Sustainability*, vol. 14, no. 10, May 2022, doi: 10.3390/su14106081.
[20] A. Gogus, "Constructivist Learning," in *Encyclopedia of the Sciences of Learning*, N. M. Seel, Ed., Boston, MA: Springer US, 2012, pp. 783–786m doi: 10.1007/978-1-4419-1428-6_142.
[21] P. V. Indu and K. Vidhukumar, "Research designs-an overview," *Kerala Journal of Psychiatry*, vol. 32, no. 1, pp. 64–67, Jan. 2020, doi: 10.30834/KJP.32.1.2019.179.
[22] C. Andrade, "Describing research design," *Indian Journal of Psychological Medicine*, vol. 41, no. 2, pp. 201–202, Mar. 2019, doi: 10.4103/IJPSYM.IJPSYM_66_19.
[23] OECD, *What kinds of careers do boys and girls expect for themselves?* Paris: OECD Publishing, 2012, doi: 10.1787/5k9d417g2933-en.
[24] J. Azevedo and M. Marques, "Climate literacy: a systematic review and model integration," *International Journal of Global Warming*, vol. 12, no. 3–4, pp. 414–430, 2017, doi: 10.1504/IJGW.2017.084789.
[25] Chairunnisa, I. Sriyanti, M. Meilinda, N. Aisyah, and Ismet, "Knowledge, Beliefs, and Attitudes of Junior High School Students in Palembang Towards Climate Change Issues," *Jurnal Penelitian Pendidikan IPA*, vol. 8, no. 2, pp. 798–804, 2022, doi: 10.29303/jppipa.v8i2.1502.
[26] K. A. Tse, "Students' perceptions on climate change and engagement in low-carbon behaviours: implications for climate change education in Hong Kong," M.S. thesis, University of Hong Kong, Pokfulam, Hong Kong SAR, 2013, doi: 10.5353/th_b5099154.
[27] J. M. Luisen, "TVL students' challenges in performance tasks despite modular distance learning modality," *Psychology and Education: A Multidisciplinary Journal*, vol. 8, pp. 322–329, 2023, doi: 10.5281/zenodo.7854567.
[28] J. Ma and Y. D. Chen, "Essential but challenging climate change education in the Global South," *Nature Climate Change*, vol. 13, no. 11, pp. 1151–1153, Nov. 2023, doi: 10.1038/s41558-023-01839-6.
[29] C. Baldwin, G. Pickering, and G. Dale, "Knowledge and self-efficacy of youth to take action on climate change," *Environmental Education Research*, vol. 29, no. 11, pp. 1597–1616, Nov. 2023, doi: 10.1080/13504622.2022.2121381.
[30] A. B. I. Bernardo, M. O. Cordel, M. O. Calleja, J. M. M. Teves, S. A. Yap, and U. C. Chua, "Profiling low-proficiency science students in the Philippines using machine learning," *Humanities and Social Sciences Communications*, vol. 10, no. 1, p. 192, May 2023, doi: 10.1057/s41599-023-01705-y.
[31] R. S. Ligsa, K. M. A. Magbanua, F. B. V. Manalo, and M. A. Romarate, "Assessing Junior High School Climate Change Literacy: Input for Learning Plan on Climate Change," *International Journal of Research and Innovation in Social Science*, vol. 8, no. 6, pp. 1377–1389, 2024, doi: 10.47772/IJRISS.2024.806103.
[32] P. M. Kurup, R. Levinson, and X. Li, "Informed-decision regarding global warming and climate change among high school students in the United Kingdom," *Canadian Journal of Science, Mathematics and Technology Education*, vol. 21, no. 1, pp. 166–185, Mar. 2021, doi: 10.1007/s42330-020-00123-5.
[33] K. Esakkimuthu and S. Banupriya, "Awareness about climate change among students: a sustainable future," *ComFin Research*, vol. 11, no. 4, pp. 1–6, 2023, doi: 10.34293/commerce. v11i4.6677.
[34] Y. Luqman, "Millennials information-seeking behavior about climate change," in *Proceedings of the 5th International Conference on Indonesian Social and Political Enquiries (ICISPE 2020)*, 2021, pp. 1–10, doi: 10.4108/eai.9-10-2020.2304814.
[35] C. Hickman *et al.*, "Climate anxiety in children and young people and their beliefs about government responses to climate change: a global survey," *The Lancet Planetary Health*, vol. 5, no. 12, pp. e863–e873, Dec. 2021, doi: 10.1016/S2542-5196(21)00278-3.

[36] L. P. Galway and E. Field, "Climate emotions and anxiety among young people in Canada: A national survey and call to action," *Journal of Climate Change and Health*, vol. 9, p. 100204, Jan. 2023, doi: 10.1016/j.joclim.2023.100204.
[37] T. J. A. Diquito, A. R. Acuña, J. R. Garcia, and J. B. C. Laganson, "Analysis of students' climate change learning using the affective domain of learning," *Revista de Gestão Social e Ambiental*, vol. 18, no. 6, p. e05908, Apr. 2024, doi: 10.24857/rgsa.v18n6-075.
[38] W. L. Filho *et al.*, "An assessment of attitudes and perceptions of international university students on climate change," *Climate Risk Management*, vol. 39, p. 100486, 2023, doi: 10.1016/j.crm.2023.100486.
[39] C. A. Jones and C. Lucas, "'Listen to me!': Young people's experiences of talking about emotional impacts of climate change," *Global Environmental Change*, vol. 83, p. 102744, Dec. 2023, doi: 10.1016/j.gloenvcha.2023.102744.
[40] K. L. Sanchez, D. G. Antipuesto, J. E. L. de Perio, and J. V. Campania, "Climate Change Awareness and Eco-Anxiety Among Undergraduate Students," *International Journal of Social Science and Education Research Studies*, vol. 4, no. 9, pp. 1017–1024, Sep. 2024, doi: 10.55677/ijssers/V04I9Y2024-10.
[41] D. C. Lundberg, J. A. Tang, and S. Z. Attari, "Easy but not effective: Why 'turning off the lights' remains a salient energy conserving behaviour in the United States," *Energy Research & Social Science*, vol. 58, p. 101257, Dec. 2019, doi: 10.1016/j.erss.2019.101257.
[42] J. P. Cameña and J. T. Castro, "Determinants of walkability and use of non-motorized transport in a medium-sized city of a developing country," *Journal of the Eastern Asia Society for Transportation Studies*, vol. 12, pp. 1311–1327, 2017, doi: 10.11175/easts.12.1311.
[43] M. J. T. Reyes and D. V. Madrigal, "Assessing students' awareness, attitude, and practices on solid waste management in a Philippine Catholic School," *Philippine Social Science Journal*, vol. 3, no. 1, pp. 9–20, 2020, doi: 10.52006/main.v3i1.125.
[44] S. Elkady, J. Hernantes, M. Muñoz, and L. Labaka, "What do emergency services and authorities need from society to better handle disasters?," *International Journal of Disaster Risk Reduction*, vol. 72, p. 102864, 2022, doi: 10.1016/j.ijdrr.2022.102864.
[45] M. Kolenatý, R. Kroufek, and J. Činčera, "What triggers climate action: The impact of a climate change education program on students climate literacy and their willingness to act," *Sustainability*, vol. 14, no. 16, Aug. 2022, doi: 10.3390/su141610365.
[46] J. L. Cabras and G. F. G. Israel, "The Relationship between Climate Change Attitude and Biodiversity Conservation Practices: The Mediating Role of Environmental Sustainability Awareness," *International Journal of Environment and Climate Change*, vol. 14, no. 8, pp. 173–181, 2024, doi: 10.9734/ijecc/2024/v14i84339.
[47] M. M. L. Dimasacat, "Tree Planting Activity to Nurture Impactful Mission (Tanim) at Select Barangay in San Jose, Batangas," *International Journal of Innovative Science and Research Technology (IJISRT)*, vol. 9, no. 8, pp. 2769–2777, Sep. 2024, doi: 10.38124/ijisrt/IJISRT24AUG1632.
[48] P. Y. Marin and L. Natividad, "The implementation of senior high school in the Philippines: an advantage or disadvantage to students' future opportunities," SSRN, 2025, doi: 10.2139/ssrn.5085709.
[49] H. M. Lagon, "Correlational Analysis on STEM Students' NCAE Scholastic Aptitude, Track Preference, and Occupational Interest, with SHS Academic Performance," *American Journal of Education and Technology*, vol. 1, no. 4, pp. 28–33, 2023, doi: 10.54536/ajet.v1i4.674.
[50] A. L. Nazareno, M. J. F. Lopez-Relente, G. A. Gestiada, M. P. Martinez, M. L. D. de Lara, and R. M. Roxas-Villanueva, "Factors associated with career track choice of senior high school students," *Philippine Journal of Science*, vol. 150, no. 5, pp. 1043–1060, 2021, doi: 10.56899/150.05.15.
[51] S. Alkair *et al.*, "A STEM model for engaging students in environmental sustainability programs through a problem-solving approach," *Applied Environmental Education and Communication*, vol. 22, no. 1, pp. 13–26, 2023, doi: 10.1080/1533015X.2023.2179556.
[52] P. M. Almerino *et al.*, "Evaluating the Academic Performance of K-12 Students in the Philippines: A Standardized Evaluation Approach," *Education Research International*, vol. 2020, no. 1, p. 8877712, Oct. 2020, doi: 10.1155/2020/8877712.

APPENDIX

Table 8. Key indicators for the proposed curriculum enhancement

Areas for enhancement	Key indicators	Objectives	Activity/procedure	Expected outcomes/results
Scientific knowledge	1. Learning competencies - curriculum guide	To strengthen the learning content and performance standards of the subjects related to CCE.	– Revisit the curriculum guide of Earth and life science, DRRR, Biology, and other CCE-related subjects through an academic forum. – Conduct needs analysis/assessment to identify the content and learning competencies that require enhancements/improvements. – Perform a root cause analysis (RCA) to identify the underlying reasons why these learning competencies are not being achieved.	– Unpacking of the learning competencies with clarity of focus – List of competencies/ topics for CCE integration
	2. Learning resources	To maximize the utilization of relevant learning resources/instructional materials, including information and communication technologies (ICT) to aid in understanding of CCE	– Conduct focus group discussions with teachers/learning resource management and development system personnel to account for the relevant learning materials for CCE through inventory assessment – Design and develop innovative learning materials (e.g., activity sheets, worksheets, and others) to enhance understanding and meet the demands for meaningful learning. – Create various digital platforms to intensify accessibility to information – Validate the learning materials crafted with experts in the field and conduct pilot testing.	Teaching resources repository and digital platforms

Table 8. Key indicators for the proposed curriculum enhancement (*continued*)

Areas for enhancement	Key indicators	Objectives	Activity/procedure	Expected outcomes/results
	3. Teacher's knowledge/ skills and competence	To enhance the capacity of the teachers to integrate the CCE into the curriculum	−-Conduct training and capacity building to strengthen the knowledge, skills, and abilities of teachers to integrate CCE through workshops, coaching, mentoring academic seminar, and others	Competent teachers/ mentors
	4. Assessment and evaluation strategies	To select strategies that support the development of students' understanding	−-Select/design various methods to evaluate students' performance, progress, and achievement. −-Analyze and interpret assessment data to improve teaching practices. −-Guide students to do a self-reflective assessment to improve their performance and achievement.	Improved performance and achievement
	5. Instructional Supervision	To monitor the level of implementation of the curriculum/ program	−Evaluate the level of curriculum/learning management competency of teachers through monitoring and providing technical assistance for improvement	Efficient implementation
Scientific competence	1. Students' skills and competence	To enhance the scientific competence of students in addressing climate change-related issues	−-Collaborate with City Disaster Risk Reduction and Management Council (CDRRMC), Department of Environment and Natural Resources (DENR), Red Cross, and other related agencies for the conduct of training/workshops for students −Collaborate with community/barangay council for awareness, engagement opportunities, and social responsibility through field trips and community immersion −Participate in science fairs to showcase the students' knowledge and skills in presenting their projects, innovations, and findings related to climate change. −Attend conferences on CCE to stay informed, network, influence policies, learn about best practices, and raise awareness.	Improved scientific competence
Scientific attitude	1. Students' attitude	To enhance the scientific attitudes of students in terms of affective and behavioral engagement in addressing climate change-related issues	−Collaborate with the guidance office and learner's support division for the conduct of psychosocial support and other related activities. −Collaborate with TLE, clubs and other school organizations for the implementation of the projects/activities (e.g. waste reduction, recycling, composting, greening, energy conservation, and others)	−Improved emotional connections with environmental-related concerns −Income-generating projects
Administrative support	1. Logistics support	To strengthen administrative/logistic support to sustain implementation	−Ensure the availability and accessibility of logistical support, supplies, and services, such as transportation, communication, medical assistance, facility usage, training services, and other related resources.	Increased efficiency and implementation
	2. Stakeholders' support	To establish linkage and support from various stakeholders	−Connect with the community/non-NGO and other stakeholders for linkages to gain support for the various programs/projects and activities (PPAs).	Effective relationship management
	3. Physical facilities	To establish a facility related to CCE to sustain effective implementation	−Establish a facility that supports the CCE, e.g. i) material recovery facility (MRF)/solid waste management; and ii) mini forest gardening/greening	Functional facilities
	4. Policies and actions	To adapt/create policies/rules in school to support CCE	−Lessen energy consumption in school −Promote the use of renewable resources and solar-powered gadgets −Strict compliance with no burning of leaves/papers/plastics −Provide opportunities for students to give feedback and participate in decision-making processes within the school.	Effective implementation
	5. Monitoring and evaluation (M&E)	To monitor and evaluate the effectiveness of the program that supports CCE	−Conduct quarterly program implementation review (PRI) −Conduct research-based assessment	Continuous improvement

BIOGRAPHIES OF AUTHORS

Hazel R. Balan is a senior high school master II at Gingoog City Comprehensive National High School, Department of Education. She has been in the teaching profession for 27 years. She earned her Bachelor of Science in Biology from Central Mindanao University and her Master of Science in Education with a major in Biology from Caraga State University. Currently, she is finishing her doctoral program-Doctor of Philosophy in Science Education with a major in Biology. Her passion for scientific research has made her a winning coach at several national science and technology fairs, where her students have also represented the Philippines at the International Science and Engineering Fair (ISEF) in Georgia, Atlanta, United States of America. She has presented research papers at national and international conferences and published scientific and educational research. She can be contacted at email: hazel.balan1976@deped.gov.ph.

Minie L. Bulay is an associate professor of Caraga State University. She garnered two masters' degrees in areas of Science Education at Philippine Normal University-Mindanao and a Special Education major in Learning Disability at Holy Cross of Davao College-Davao City. She completed her doctoral degree major in Biology at the University of San Carlos-Talamban, Cebu City, Philippines. Currently, she is connected to the College of Education, Caraga State University, Ampayon, Butuan City. She is designated as the Program Chair in the graduate science education programs in the college. Her fascination and stint in research made her published and co-authored research articles in Scopus, Web of Science, and highly refereed peer-reviewed international journals. She also co-authored the Manobo Dictionary and Field Studies 2 Workbook, which are used by pre-service teachers at the university. Her broad experience in the field of education from both tertiary and basic education for 23 years made her pliant in understanding the complex personalities and learning abilities of the students. She can be contacted at email: mlbulay@carsu.edu.ph.

Nelia S. Raganas is a retired professor VI at Caraga State University. She had been in the academe since 1983 and had been a recipient of scholarship programs for her master's and doctorate degrees. She finished her Ph.D. Mathematical Sciences at the University of Science and Technology of the Philippines. She has a great passion for research and had written books in different areas of teacher education. Presently, she is the Graduate School Dean of Agusan Colleges, Inc., one of the renowned private HEI in Caraga Region. She can be contacted at email: nsraganas55@gmail.com.