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Reinforcing the Perception of Climate Education and Educational Climate among Academicians and Practitioners in Banten Province through Collaborative Learning

Clara Shabrina Parameswary
Universitas Sultan Ageng Tirtayasa, INDONESIA

Sandi Danar Cynthia Sari*
Universitas Sultan Ageng Tirtayasa INDONESIA

Tresna Galih Sukma Suryana
Universitas Sultan Ageng Tirtayasa INDONESIA

Devi Ayu Nur'aini
Universitas Sultan Ageng Tirtayasa, INDONESIA

Dinar Nirmalasari
Universitas Sultan Ageng Tirtayasa INDONESIA

Dudung Abdurrahman
Universitas Sultan Ageng Tirtayasa INDONESIA

Annisa Novianti Taufik
Universitas Sultan Ageng Tirtayasa, INDONESIA

Sindanita Yulianty
Universitas Sultan Ageng Tirtayasa INDONESIA

Dewi Murni
Universitas Sultan Ageng Tirtayasa INDONESIA

Tri Retno Wulan
SMAS Informatika, Serang Indonesia (IGI), INDONESIA

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Abstract

Climate education (literacy and awareness of climate) and educational climate (pedagogical atmosphere) are two closely related concepts whose implementation is vital in education. The reinforcement of these two aspects is sometimes less highlighted in scientific forums. This event aims to provide enrichment for higher education institutions, teachers, and stakeholders in Banten Province regarding these two themes. The event was organized by lecturers from the science clusters (comprising mathematics, physics, chemistry, natural sciences, and biology) at FKIP Untirta in collaboration with the Association of Indonesian Teachers in Serang City (IGI Kota Serang). The event began with an interactive talk show followed by an active sharing session involving participants who were grouped according to their subject areas or fields of study and enriched with demonstrations of learning media and instruments to support the implementation of climate education and school climate practices. The research was conducted to examine the perceived usefulness and knowledge gain of participants regarding the event. Data were collected from respondents through an online survey, and qualitative analysis was conducted. The data were interpreted descriptively. More than half of the participants had limited prior understanding of the topic; however, participants reported an increase in knowledge and confidence in implementing and integrating climate education and educational climate in schools. In conclusion, most participants perceived the event as successful in strengthening ideas related to climate education and in promoting the implementation of educational climate in schools.

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* **Corresponding author:**
Sandi Danar Cynthia Sari, Universitas Sultan Ageng Tirtayasa, INDONESIA. ✉ sandidanarcs@untirta.ac.id
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INTRODUCTION

Indonesia has been reported ranked 43rd in the Climate Change Performance Index (CCPI) denoting a low performer in categories involving greenhouse gases emissions, renewable energy, climate policy, and energy use (CCPI, 2026). This situation has direct impacts on climate change that affect the population in Indonesia. However, the Indonesian school curriculum still lacks adequate coverage of climate change topics. As a result, comprehensive climate literacy is difficult to achieve if it relies solely on the formal curriculum without additional reinforcement. Climate education is part of sustainable development key issues, as defined by UNESCO (2024), which integrates key sustainability topics into teaching and learning, including climate change, disaster risk reduction, biodiversity, poverty reduction, and sustainable consumption. Three key areas of education for climate action include climate literacy for advocacy and behavioral change, the development of green skills for future economic needs, and quality education as an adaptation strategy to support climate empowerment (Ehlers et al., 2021). This aligns with the Intergovernmental Panel on Climate Change (IPCC) perspective, which emphasizes that education and information must work in synergy to enhance public capacity in addressing climate-related challenges and improving decision-making. Information derived from scientific research should be communicated through structured education in both formal and informal settings. According to the IPCC (2018), education and information function as mechanisms to build environmental awareness and sensitivity in society.

To increase environmental knowledge, awareness, and sensitivity toward climate change, climate-related topics must be integrated into the educational curriculum, particularly at the secondary education level, where students have developed sufficient cognitive, contextual, and critical thinking skills. In this study, education is viewed as a strategic solution to the climate crisis and aligns with Sustainable Development Goal 13, which focuses on urgent climate action and mitigation strategies. However, teachers at the secondary school level have reported difficulties in delivering climate change education due to limited conceptual understanding of the topic (Hamid et al., 2024; Leve et al., 2023; Plutzer, et.al., 2016). The implementation of climate education in schools remains challenging, particularly in integrating teaching instruments and practical learning tools. Previous seminars often focus only on theoretical discussions and lack practical demonstrations using teaching media that support comprehension across different subjects. In contrast, the current program integrates theoretical sessions, discussions, and hands-on demonstrations using educational tools to support classroom implementation. This approach aims to address the gap between conceptual understanding and practical application of climate literacy among educators.

Monroe et al. (2019) stated that effective environmental education includes personally relevant and meaningful content as well as active and engaging teaching methods. Climate change education should involve deliberative discussions, interaction with scientists, addressing misconceptions, and implementing school or community-based projects. They further proposed that climate education should be structured into cognitive, socio-emotional, and behavioral learning domains. Therefore, an integrative approach is required to ensure students not only understand climate issues but also apply their knowledge in real-life actions. Szczepankiewicz et al. (2021) emphasized that climate education should begin at early childhood education (2–6 years), continue through primary and secondary education (7–18 years), and extend to higher and adult education. At the school level, climate education can be implemented through formal curricula, field trips, eco-projects, and environmental competitions. Therefore, educators must have a strong understanding of both conceptual frameworks and implementation strategies.

The minimum degree of awareness for climate education of students in Banten was depicted by a study from Khastini, et.al. (2024) that performed a purposive sampling in two Adiwiyata High Schools (high schools that have received certification from government as schools that have succeeded in applying environmental literacy in school life) in Serang, Banten. The research analysis was performed using Pearson correlations, linear regression and path analysis to understand the relationships between environmental knowledge, self-regulation and attitudes toward environmental conservation. The study from 150 student respondents showed the average self-regulation score was 76.25%, the environmental score was 64.10%, and the environmental attitude was 79.40%. These findings indicated that, although situated in a school with high environmental awareness, a government certified ‘Adiwiyata school’, the overall assessment results showing

environmental knowledge, self-regulation, and attitudes toward environmental issues were not optimum, especially in the environmental score, which only scored less than 70%. The environmental score comprises three indicators related to environmental knowledge: environmental problems, environmental science, and ecology, with the least performance on knowledge of environmental science, with only 62.7%. This was found to be ironic, and it suggests that there is a considerable urgency to strengthen climate education among students in Serang, Banten, where this event was held.

Masuroh & Mardani (2024) proposed strategies for integrating climate change education into school curricula, including embedding climate topics across subjects, applying experiential learning, and training teachers to deliver climate-related content effectively. They also reported that climate education improves environmental awareness and strengthens students' sense of responsibility toward sustainability. Therefore, collaborative programs involving lecturers, teachers, and stakeholders are essential to enhance implementation effectiveness.

Educational climate refers to the quality and character of school life, which includes norms, values, and expectations that support people feeling socially, emotionally, and physically safe (Cohen et al., 2009). In addition to that, Wulan & Sanjaya (2022) in their study concluded that characteristics of positive school climate for inclusive education were categorized into sense of physical and socio-emotional security, learning process that supports student self-development as a whole, supportive relationships and respect for individual differences, school environment that creates sense of belonging and encourages active participation of school members, leadership and professional relationship that cultivate positive attitude toward inclusive education.

La Salle-Finley et al. (2024) suggested that a positive educational climate might be associated with more prosocial behaviors, academic achievement, reduced engagement in risky behaviors, teacher retention, and reduced burnout. They also proposed some interventions, such as transnational and transdisciplinary approaches in understanding students' identities, their educational experiences, and their academic, social, emotional, and behavioral characteristics in order to provide support for bringing a positive school environment.

Fauziah et al. (2024) proposed that a safe and comfortable environment includes 1) a pleasant school atmosphere for students and teachers, adequate facilities, and a mutually supportive atmosphere, 2) a safe environment, 3) a comfortable environment, and 4) school policies that lead to restrictions and regulations regarding discipline. Yuda et al. (2023) stated that students perceived that a conducive school climate includes aspects of healthy relationships, good change and improvement of the school system, a good physical environment, and supportive personal development. Based on the description above, a conducive school climate can be defined as a comfortable and supportive environment for educational activities, one in which teachers and staff experience well-being and collaborate in alignment with the school's established vision and mission, and where students can achieve academic success. Sitepu & Sulasmi (2023) stated that creating a conducive school climate is an ideal that is often difficult to fully achieve. A conducive school climate requires effective management and continuous maintenance, involving the active participation of the principal, teachers, and school staff. Each staff member assumes responsibility for their primary duties and functions, takes pride in their profession and the institution in which they work, fosters warmth within the social environment, supports school programs, and, most importantly, ensures that conflicts within the school do not hinder progress or create unresolved tensions. Although the principal plays a highly strategic role in steering the school toward its vision, their success depends on the support of all school stakeholders, particularly the teachers.

Therefore, it is essential to implement programs that empower teachers to become leaders who actively drive positive changes in schools and to develop as professional educators. This is particularly important in the context of climate education, where teachers play a critical role in fostering environmental awareness, integrating sustainability principles into the curriculum, and shaping student attitudes and behaviors toward climate action. Most of the workshops on climate education and educational climate only covered two-way communication conducted generally, neglecting the needs of close, thoughtful, and focused group discussion according to the needs of teachers from different fields, and often lacking in the direct sharing of knowledge or instruments used in learning and teaching. This event combined lectures, two-way discussion, and comprehensive discussion, enriched by some corresponding activities as guidance for implementation at school.

METHOD

The educational events were adapted from a design-led event model involving a multi-stage collaborative planning process (AlWaer et al., 2021). Within this framework, each stage was operationalized through coordinated planning sessions among the organizing partner. The event was organized by lecturers from Mathematics, Physics, Chemistry, Biology, and Science Education cluster (MAFIKIBIPA) in the Faculty of Teacher Training and Education (FKIP) Universitas Sultan Ageng Tirtayasa, in collaboration with the Indonesian Teachers Association, Serang City Chapter (Ikatan Guru Indonesia/IGI Kota Serang). A total og 203 participants participated in the event, consisting of teachers from across the Banten region, education stakeholders, faculty members, university lecturers, and undergraduate students. Of these, 97 participants completed the post-event questionnaire.

The program adopted an adapted Community-Based Participatory Research (CBPR) approach (Israel et al., 1998; Wallerstein & Duran, 2006), contextualized for an educational setting following the framework previously done by Arjaya et al. (2025). In the original CBPR framework, community members are engaged as co-researchers across all stage of inquiry. In this adaptation, the community was reconceptualized as an educational community comprising the teachers' association (IGI Kota Serang), university lecturers and students, and local education stakeholders.

The core CBPR principles are implemented through shared decision-making, community co-ownership, iterative reflection, and reciprocal benefit (Collins et al., 2019). Shared decision-making is carried out through joint planning meetings between the MAFIKIBIPA cluster of Faculty Teacher Training and Education Untirta, and the IGI. Community co-ownership is achieved through the IGI's active role in determining the topics and formats of activities. Iterative reflection is carried out by evaluating each stage. The reciprocal benefit for the university is that this activity implements the *tri dharma* of higher education, while for teachers, it serves as a means of enhancing pedagogical competence.

The adapted CBPR stage comprised: (1) Initial Observation that covers planning, constructing the committee, and pre-event survey as part of the need assessment to identify relevant climate education topics. (2) Program Development, involving enhanced coordination between the organizing committee and invited speakers to align content with identified needs. (3) Program Implementation, consisting of the main event activities, both workshop sessions, and a parallel class. (4) Program Output Preparation, including the questionnaire construction, was validated through four lecturers who are experts in the field of science education, and was rated as "highly appropriate". (5) Program Evaluation, which includes data collection and analysis. Figure 1 presents the CPBR adapted workflow.



Figure 1. CPBR adaption workflow

There were two consecutive programs conducted in the event, which was started by a workshop on the importance of climate education and educational climate by experts. After attending the talk show in the main hall, the participants were directed to the classes in accordance with their field. There were six classes provided by the committee, as summarized in Table 1.

Table 1. Summary of Parallel Classes

No	Class	Topic	Facilitator	Participant
1.	IGI	Enhancing teacher professionalism and instructional quality	IGI	Primary School Teacher dan Social Studies Teacher
2.	Chemistry	Science Simulation and Climate Change Media	Chemistry education lecturers	Chemistry teachers & students
3.	Physics	STEM-Based Learning Media for Climate and Energy	Physics education lecturers	Physics teachers & students
4.	Biology	Virtual Labs as an Alternative Solution	Biology education lecturers	Biology teachers & students
5.	Mathematics	Deep learning in the context of pedagogy	Mathematics education lecturers	Mathematics
6.	Natural Science	Ethno-STEM based learning	Natural Science education lecturers	Natural science teachers

Each class incorpotayed pedagogical approaches including Problem-Based Learning, where participants analyzed real-world climate related problems relevant to their subject areas; Project-Based Learning, where participants collaboratively designed classroom applicable projects; and Participatory Learning, defined here as an approach in which all attendees actively contributed to discussions an co constructed knowlegde (Heron, 1996).

An online questionnaire surveys has now been adapted in the methodological ways for receiving feedbacks from respondents as this method offers a feasible and effective way in collecting data, as it comprises six methodological components that are critical to successful online surveys: a) user-friendly design and layout; b) selecting survey participants; c) avoiding multiple responses; d) data management; e) ethical issues; f) piloting tools (Regmi et al., 2017). Data were collected using a structured questionnaire administrated via Google Forms platform immediately after the completion of all event activities. Google Form was selected as the data collection platform due to participants' prior familiarity with the tool, ensuring ease of access and minimizing technical limitations.

The questionnaire for respondent's response toward the events listed several statements and participants were asked to choose one of the options on a four-point Likert scale (4=strongly agree, 3=agree, 2=disagree, 1=strongly disagree). These item assessed six aspects: (a) Quality of Performance and Facilitation, (b) Knowledge Gain, (c) Initial Knowledge Gap, (d) Relevance and Usefulness, (e) Confidence and Intent to Implement, and (f) Awareness and Sustained Interest. There were also comment sections for the participants to write testimonials and suggestions regarding the event. Data collected from the questionnaire was qualitatively analyzed and presented in descriptive narration.

RESULTS AND DISCUSSION

The event was conducted on Tuesday, June 17th 2025 in the Faculty of Teacher Training and Education (FKIP) Untirta. The event comprised two main components: (1) a workshop session featuring expert presentations on climate education and educational climate, and (2) six parallel classes designed to strengthen participants' understanding and practical skills. The details of the events are presented below, with analysis and explanation of the events as well as survey findings are described extensively within each sub topics.

Workshop Session: Climate Education and Educational Climate

The workshop session was the sharing session which was moderated by Mrs. Ida Maryamah, that led the talks from Prof. Dr. Anis Fauzi, a professor in politics and education policy UIN Sultan Maulana Hasanuddin, Banten and Dr. Erisda Eka Putra as a curriculum developer in the center of curriculum and learning in the Ministry of Primary and Secondary Education in Indonesia. Figure 2 depicts some documentation from the sharing sessions that showcases the enthusiasm of participants including the active participation in asking questions, giving feedbacks and discussing experiences in implementing the educational climate at school.



Figure 2. Documentation of workshop session

Mr. Anis in his talk stated that good educational climates should be shaped by a good cooperation between educators, students, family, and stakeholders. The ease of access for education still became a limitation to some people who lived in rural areas. This showed that in this condition or this climate, we will face challenges, and the change of this educational climate should be perceived as a problem to be solved. This is the thing that we should work on to actualize a good educational system.

Mr. Erisda opened the talk with a video of a child song, entitled 'Bangun Tidur' (a popular children song that tells the activities after waking up in the morning) that represented a good habit that should be embraced by everyone to be an outstanding student, starting from the morning routines. He highlighted the importance of building good habits as foundational to positive educational climate. He also proposed that we need to see the motivational factors and pre-conditions to ease the process of starting and maintaining good habits. The worksdhop sessions were closed by the delivery of summary by the moderator. Some documentations were captured during the event, as shown in Figure 2.

Participants Profile

Of the 203 participants, 97 completed the questionnaire. The low response rate (97 out of 203 participants) was due to several factors. The questionnaire was announced and distributed after the first event and many participants had already left the room or were not interested in filling it out. Moreover, the questionnaire was made optional, therefore there was no sense of obligatory task to fill out the survey. The demographic composition of survey respondents is summarized in Table 2.

Table 2. Demographic Profile of Survey Respondent

Category		n	%
Profession	Teachers	64	66,0 %
	Lectures	6	6,2 %
	Undergraduate Students	25	25,8 %
	Stakeholders	2	2,1 %

The majority of survey respondent were teachers which corresponds 66% of the total participants, while lecturers, stakeholders and university students contributed 34% in total. This combination is very appropriate for the main target audience of this event, which is active educators, while still incorporating valuable perspective from other education stakeholders.

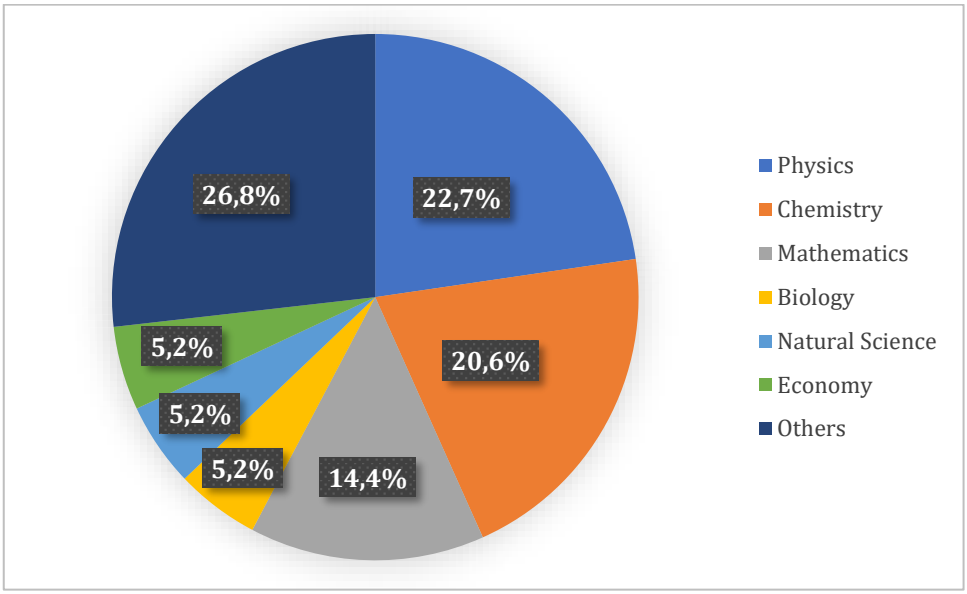


Figure 3. Distribution of participant's area of expertise

Participants' area of expertise was distributed among different subjects of teaching, as shown in Figure 3, marking on 22,7% from Physics, 20,6% from Chemistry, 14,4% from Mathematics, 5,2% from Natural Science, 5,2% from Biology, 5,2% from Economy, and the remaining 26,8% were distributed in a small percentage for other subjects: history, geography, English, counseling and guidance, special education, civics education, arts, etc. The diverse profile of respondents suggest broad outreach across disciplines. However, the extent to which the samp;e represents the target population requires further analysis, particulary given the 52% no-response rate.

Respondents' Perception on the Event: Analysis of the Survey

Participants' responses to the event regarding each aspect of the survey are presented in Table 3. The 'Agree' precentage represents the combine proportion of participans who selected 'Strongly agree' or 'Agree', while the 'Disagree' persentege represents the combined proportion of those who selected 'Disagree' or 'Strongly disagree'.

Table 3. Percentage of Participants' Responses by Aspect

Survey Aspect	Agree (%)	Disagree (%)
Quality of Performance and Facilitation	99,7%	0,3%
Knowledge Enhancement	100,0%	0,0%
Initial Knowledge Gap	89,2%	10,8%
Relevance and Usefulness	99,5%	0,5%
Confidence and Intent to Implement	98,5%	1,5%
Sustained Awareness and Interest	100,0%	0,0%

Regarding the event's execution, 99,7% of respondents showed a positively agreed response on *Quality of Performance and Facilitation* aspect, which include the smooth running of the event, the interactive and skilled delivery of material by the speakers, and the engaging discussions and content in the workshop and parallel sessions. The *Initial Knowlegde Gap* aspect was reflected in the fact that the event's theme was considered as new for the participants. 89,2% of participants agreed, indicating that the majority of participants anknowledged their lack of prior knowledge related to the themes. Conversely, 10,8% diagreed, indicated that a small proportion of respondents felt they

already had some knowlegde or experience with the climate education prior to the event. A similar condition was also observed on a study by Meilinda, et.al. (2017) which found that more than 50% of science teachers and pre-service science teachers in their study held misconceptions about climate change. The background of the participants might be associated with this finding. Less percentile of the participants might have been exposed to climate literacy or might have integrated climate education and educational climate at school prior to the event. In the aspect of *Knowlegde Enhancement*, which includes statements regrading understanding of climate change concepts and impacts, as well as increased knowlegde following the workshop and parallel sessions, the result show that 100% of participants agreed, while 0% disagred. This unanimous agreement indicates that every participant experienced a significant increase in their understanding of climate change and its environmental impacts during the event's session.

In the aspect of *Relevance and Usefulness*, 99,5% participants agreed that events material was relevant to their needs and benefical to them. The content directly applicable to their professional roles as educators and perceived the session as valuable in supporting their teaching practices. In the aspect of *Confidence and Intent to Implement*, 98,5% of participants agree that the event successfully enhanced teachers' self-efficacy and commitment to applying climate education content in their own classrooms, so that these materials can be applied in their teaching practices. In the aspect of *Sustained Interest and Awareness*, all participats agreed that the event had increased their awareness of the importance of teaching about climate change and its environmental impacts, as well as their interest in attending future events. This perfect agreement demonstrates that the event not only succeded in increasing teachers' awareness of the urgency of climate education, but also fostered a alsting commitment to pursue future professional development opportunities.

According to the comments on questionnaire, participants expressed appreciation for the quality of the speakers, the inspiring themes and the event's benefit in enhancing their knowledge and teaching motivation. However, several suggestions for improvement should be considered for future events, including: extending the duration so that the speakers'presentation session are not rushed, improving the readliness of facilities and teaching aids, organizing more specialized parallel sessions based on all field of study, and providing worksheet or practical materials that participats can take home to apply in their schools while teaching.

Parallel Session: Practical Innovations and Teaching Strategies for Climate Education

The parallel session was directing participants to the specialized classes provided by the committee to enhance and strengthen the understanding among academicians related to the topics, which might be related to the subfield in accordance.

Parallel Class of IGI

A number of facilitators from IGI (Indonesian Teachers Association) Kota Serang delivered presentations covering complementary themes aimed at enhancing teacher professionalism and instructional quality. The first theme, *Strategies and Good Practices in Teacher Communities*, was presented by Indra Martha Rusmana, M.Pd., and Najarudin, S.Pd. This session highlighted the significance of strengthening learning communities as platforms for sharing best practices, engaging in collective reflection, and fostering instructional innovation. As emphasized by DuFour, R., et.al. (2006), effective learning communities can significantly improve student learning outcomes through teacher collaboration and data-informed decision-making. Teachers communities enhance climate education through collaborative knowlegde sharing, reflection, and evidence-based learning, while building trust and reducing feelings of isolation to foster a positive educational climate.

The second theme, *Building an Educational Climate*, was delivered by Wahyu Fatihah, M.Pd., Luda Sofiah, M.M., and Thoriq Majid, M.Pd. This session stressed the importance of creating a supportive, safe, and inclusive educational environment, which is a critical precondition for effective learning. A positive school climate has been shown to correlate with increased student motivation, teacher engagement, and reduced negative behaviors (Cohen et al., 2009). The session concluded with a book review entitled *Building Up Educational Climate*, written by a team of educators from Banten Province. The book documents exemplary practices and reflections from teachers in their efforts to establish a conducive school climate and contributes to educational literacy both locally and nationally. The documentation of activities in IGI parallel class is shown in Figure 4.



Figure 4. Documentation of IGI parallel class

Parallel Class of Chemistry

Dr. rer. nat. Robby Zidny, S.Pd., M.Si. and Imas Eva Wijayanti, M.Si gave presentations with theme *Science Simulation and Climate Change Media*. The integration of science simulations and climate change media in chemistry education contributes significantly to enhancing students' understanding and engagement with complex and abstract chemical concepts. Chemistry, as a subject that frequently involves microscopic and dynamic processes—such as molecular interactions, reaction mechanisms, and thermodynamic changes—often poses cognitive challenges for learners. Visualizing such phenomena through conventional instruction can be difficult, particularly for students with limited prior knowledge or low spatial reasoning skills. In this context, digital science simulations play a crucial role in providing interactive, visual, and real-time representations that bridge the gap between abstract theory and observable understanding.

Research has shown that students who learn using simulations demonstrate improved mental models and greater retention of scientific processes compared to those taught through traditional methods (Rutten et al., 2012; Wu & Shah, 2004). Simulations not only support visualization but also foster active engagement through exploratory learning environments where students can manipulate variables, test hypotheses, and receive immediate feedback. This process aligns with constructivist learning principles, which emphasize that knowledge is best constructed through meaningful interaction with content and tools.

After the introduction was delivered, facilitators and students from chemistry education department FKIP Untirta demonstrated some experiments of their research projects that are related to the theme. Projects and products presented in the class include: experiments of greenhouse gas effect, simulation of carbon capture storage, development of grow foam media, modules related to hydrocarbon and green chemistry, various forms of student worksheets (LKPD): e-LKPD, digital flip book LKPD, and LKPD related to green chemistry and socio-scientific issue material, laboratory instructions for green chemistry, animated video for green chemistry learning media. Figure 5 shows the activities provided in chemistry parallel class.



Figure 5. Documentation of chemistry parallel class

Parallel Class of Physics

Representatives of lecturers from the Physics Education Department, FKIP Untirta, presented several research studies related to climate and energy. Various research findings from the lecturers as well as learning media were introduced during this event. The session began with a presentation on recent research related to climate and disasters in Indonesia by the team led by Prof. Yayat Ruhiat, M.Si. The development of media by several lecturers and teams concerning climate and energy included the following innovations: (1) Yuvita Oktarisa, Ph.D's team presented learning media for observing global warming; (2) Hayatining Suci Abdillah, M.Si.P presented a miniature of a Micro Hydro Power Plant (PLTMH) as a learning media; (3) Yudi Guntara, M.Pd and colleagues presented a Physics Parameter Monitoring System (PPMs) of UV radiation to educate about melanoma damage, which is one of the impact on human health from ozone layer depletion caused by climate-impacting emissions; (4) Ganesha Antarnusa, M.Sc and team demonstrated laboratory instruments used in free-fall experiment; (5) Annisa Ulfa Yana, M.Pd introduced a student worksheet based on the 5E (Engage, Explore, Explain, Elaborate, and Evaluate) learning model for the free-fall experiment. These free-fall experiments relate to climate education through the STEM pedagogical approach by forming conceptual understanding on data literacy, modeling skills, and investigative practices that are important when applying to analyzing climate data and environmental systems. Figure 6 shows some pictures taken in the parallel class of physics during the session.

Various media presented by the physics lecturer team have been tested on students. The use of different teaching kits related to global warming topics received positive responses from the students (Dwimuhaqaida et al., 2025). In addition, the PPMs learning media also increased student participation and conceptual understanding (Nala et al., 2025). Based on the fact that physics learning media in schools are still limited in variety due to teachers facing difficulties and lack of time to develop learning materials (Eliezanatalie & Deta, 2023), this community service activity is expected to introduce and inspire teachers in their efforts to facilitate the physics learning process. Media plays a significant role in providing richer information, encouraging adaptive learning patterns, and offering innovative solutions (Azhura, P. D., et.al., 2024). The effectiveness of learning depends on the technology and the teachers' skills in developing learning tools (Maslakhah et al., 2024). Various physics learning media such as visual, audio, digital, interactive, and innovative technologies hold an important role in helping students understand physics concepts and principles (Alifteria et al., 2023).



Figure 6. Documentation of physics parallel class

Parallel Class of Biology

During the parallel biology session, a training on using the Virtual Lab Application with PhET, a specific platform of virtual lab for science subjects, was presented by Dr. Dewi Murni, M.Si. to discuss virtual labs as an alternative solution for biology practice in schools, the importance of virtual labs and various types of virtual labs. After the explanatory session, participants were divided into small groups to try out various free virtual lab websites. In this activity, facilitators help the participants explore many features of the virtual lab and engage in more in-depth discussions about their experience in conducting practical experiments. After discussion in the small group, participants presented their experience after using the virtual lab and their potential applications in schools.

Wulandari et al. (2025) found that the implementation of biology practicum in high schools in Serang City had many obstacles, including limited tools and materials, limited practicum time, and

a lack of utilization of the surrounding environment. These problems can reduce the effectiveness of practicum and affect the quality of learning received by students. Through this training, it is expected that teachers will be inspired to use virtual labs as alternative solutions to facilitate practical work in their schools.

Virtual laboratories have shown a positive impact in enhancing biology education. Studies indicate that virtual labs can improve students' conceptual understanding and independent learning in topics like animal tissue structure (Wati, 2021). Salem & Lakwani (2024) suggested that biology students enjoy the availability of a safe and controlled environment while conducting laboratory experiments, which contribute to enhance and deepen the understanding of various complex fields in biology, while minimizing the risks associated with the conventional laboratory environment. Nasution et al. (2023) suggested that a virtual laboratory is very feasible to use for observation of protists gaining validity of media of more than 80% and validity of materials more than 90%. This highlights the benefits of using virtual laboratories as an alternative method for biology students. Research by Ahmad and Nur (2024) and Rana et al., (2023) also found that using virtual biology laboratories effectively improves student learning outcomes. Therefore, this session is expected to increase laboratory activities and students' outcomes in the future. Figure 7 shows the participant's activity in biology parallel class.



Figure 7. Documentation of biology parallel class

Parallel Class of Math

The topic given in this section was about deep learning in the context pedagogy in mathematics. Deep learning in mathematics provides tools (modeling dan data analysis), while climate education provides the relevant context dor applying those tools. The pedagogical deep learning approach emphasizes experiential, participatory, and student-centered learning (Agyeman, 2024). In the beginning of the session, the participants were asked to conduct a pre-test related to basic knowledge of deep learning. Then, Ade Nantang Mustafa, Ph.D. delivered an explanation 'Introduction to Deep Learning' and Dr. Aan Hendryana, M.Pd. explained 'Deep Learning Approach'. After the explanation session, then came the interactive discussion session that allowed participants to be actively engaged in sharing knowledge and experience (Sendhitasari et al., 2024). It was also filled with an ice-breaking session, then post-test was conducted. At the end, participants were asked to design a classroom learning activity using deep learning approach. Figure 8 shows the documentation of math parallel class.



Figure 8. Documentation of math parallel class

Parallel Class of Natural Science

The topic brought in natural science class was enrichment of knowledge and capacity of teachers related to Ethno-STEM in climate education to integrate the Ethno-STEM-based-learning in the class. This Ethno-STEM approach integrates indigenous knowlegde with modern science (STEM) to understand, mitigate, and adapt to climate change. The session was started by discussing the concept of Ethno-STEM (Ethno-Science, Technology, Engineering, and Mathematics), which was an approach of scientific learning that was correlated with local wisdom, tradition, and culture in the STEM framework. Integration of STEM and ethnoscience enables students to understand application of science in real life, especially through technology that is based on local wisdom that has been passed through generations (Maryanti et al., 2023; Sumarni et al., 2023). In Banten, local wisdom related to climate issues includes agricultural traditions that adapt to seasonal changes, coastal knowlegde for disaster mitigation, traditional water management practice, and culturally-based environmental conservation efforts carried out by the Baduy community. This shows that Banten indigenous people has been applying their local wisdom into climate education in informal scheme. The discussion was conducted interactively, persuading teachers and all participants to be active in discussing the possible local wisdom that are relevant to be developed in natural science learning, specifically in climate change issues. After the explanation of Ethno-STEM, there was training related to development of LKPD that is based on Project Based Learning with a theme of climate change. Finally, there were sharing sessions with the teachers to discuss, evaluate, provide feedback, and make a draft of LKPD to be implemented at their schools. Figure 9 shows the documentation of the natural science parallel class.



Figure 9. Documentation of natural science parallel class

Analysis of the Educational Props

Several educational props were provided and/or demonstrated in each parallel class in addition to materials given from the speakers. These include worksheets (*Lembar Kerja Peserta Didik*), teaching module, laboratory module, laboratory experiments, and virtual demonstration. Table 2 listed the problem found in the class in educating climate and creating a conducive and well-maintained educational climate at school with the corresponding solution.

Table 2. Problem solution analysis

No	Problem	Solution	Output
1	Science learning remains theoretical, lacks contextual relevance, and has minimal use of interactive digital media.	Development of research-based learning media, experiments, and integration of global issues such as climate change and energy.	Worksheets (LKPD, e-LKPD, digital flip book LKPD)
2	Limited practicum resources at schools; lack of tools and materials, limited practicum time, and a lack of utilization of the surrounding environment.	Development of virtual labs or worksheets that integrates into available virtual lab websites accomodate this limitation on resources	Virtual Lab, worksheet integrated to virtual labs

No	Problem	Solution	Output
3	Students have difficulty understanding abstract scientific concepts such as chemical reactions, energy transformations, or particle interactions.	Design of simple and low-cost experiments using household materials to visualize abstract phenomena.	Home-based experimental kits, guided experiment videos, experiment worksheets
4	Students have difficulty visualizing abstract scientific concepts (e.g., the greenhouse effect, electricity flow, or plate tectonics).	Creation of physical models or miniatures to represent abstract processes in a tangible, visual, and interactive way.	Miniature of a Micro Hydro Power Plant, Physics Parameter Monitoring System

CONCLUSION

A collaboration between academicians and practitioners from Faculty of Teacher Training and Education (FKIP) Untirta, IGI Kota Serang, several stakeholders and teachers from Banten province, and also university students have shown an increasing awareness, knowledge and technological skills in integrating climate education and educational climate at school. A questionnaire comprising several statements has demonstrated that respondents positively agreed that the event was conducted successfully. The *Knowledge Enhancement* and *Sustained Awareness and Interest* categories achieved 100% agreement, while *Quality of Performance and Facilitation* achieved 99.7%, *Relevance and Usefulness* 99.5%, *Confidence and Intent to Implement* 98.5%, and *Initial Knowledge Gap* 89.2%, indicating that the majority of participants acknowledged an increase in knowledge compared to their initial level. The participant's feedback highligthed their appreciation for the highly-qualified speakerd, the inspiring and relevant topics, and the event's value in inhancing their knowledge and motivation to teach. The parallel classes were described as engaging, interactive, and a great way to gain new skills that can be applied in the classroom. Future events associated with these topics might bring more reinforcements at schools, i.e. through follow-up mentoring, discussion, and evaluation after implementation at schools.

AUTHOR CONTRIBUTIONS

C.S.P., S.D.C.S., and T.G.S.S. contributed to study conception, theoretical framework development, and research design related to climate education and educational climate; D.A.N., D.N., and D.A.A. contributed to data collection through survey distribution, respondent engagement, and field coordination during the collaborative learning event; A.N.T., S.Y., D.M., and T.R.W. contributed to data processing, descriptive analysis, and interpretation of participants' perceived knowledge gain and learning outcomes

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