Teacher Empowerment in the Implementation of Low Carbon Education to Increase Students' Environmental Awareness

Riezky Maya Probosari, Muhammad Nur Hudha*, Icha Kurnia Wati, Annisa Nur Khasanah, Supurwoko

Universitas Sebelas Maret, Ir. Sutami St. No.36, Surakarta, Central Java, 57126, Indonesia
*Corresponding author, email: hudha.mn@staff.uns.ac.id

Article History
Received: 21 June 2025
Revised: 1 August 2025
Accepted: 2 August 2025
Published: 3 August 2025

Keywords
Carbon emissions
Environmental awareness
Low carbon education
Science learning
Sustainable education

Abstract
Environmental problems due to excessive carbon emissions are increasing, while student awareness of this issue is still low. Science learning has great potential in instilling sustainability values. Therefore, this service aims to empower teachers in one of the junior high schools in Central Java in designing and implementing Low Carbon Education (LCE) based learning. The short-term goal of this activity is to improve teachers' understanding of the concept of low carbon and its application in learning. In the long term, teachers are expected to be able to develop learning innovations that are more contextualized and can apply students' low carbon lifestyle in their daily lives. The methods used include socialization of the LCE concept, development of low carbon-based learning tools, implementation in the form of simple experiments and environmental projects, and program evaluation. The results show an increase in teachers' understanding of LCE and the emergence of applicable environment-based learning projects. The main contribution of this program is the availability of a model for teacher capacity building in implementing LCE that can be replicated in other education units, while contributing to climate change mitigation efforts through education.

How to cite: Probosari, R. M., Hudha, M. N., Wati, I. K., Khasanah, A. N., & Supurwoko. (2025). Teacher Empowerment in the Implementation of Low Carbon Education to Increase Students' Environmental Awareness. *Teaching, Learning, and Development*, *3*(2). 169–174. doi: 10.62672/telad.v3i2.97

1. Introduction

Education is identified as a critical factor in cultivating a generation that demonstrates a commitment to environmental sustainability (Rozi et al., 2024). In the contemporary era, a range of environmental challenges, including pollution, climate change, and energy crises, necessitate a fundamental transformation in the educational paradigm. A potential solution to this issue is Low Carbon Education (LCE). The LCE approach endeavors to cultivate sustainable mindsets and behaviors by reducing carbon emissions in the early stages (Rahmayanti & Ilyasa, 2022). The implementation of low-carbon education is predicated on the dual objectives of fostering student learning in scientific theory and equipping them with the competencies to confront the manifold, progressively intricate environmental challenges that characterize the contemporary era (Hermanto et al., 2025). Consequently, the integration of LCE in science education signifies a deliberate strategy to inculcate environmental consciousness among young learners.

However, the implementation of low-carbon education in schools, particularly in junior high schools of partner schools, still faces several obstacles. A significant challenge lies in the conventional and limited variety of learning methods, which results in minimal student engagement in the learning process. Research indicates that learning models that do not promote active student engagement may impede the development of critical thinking skills (Afifah, 2021). Furthermore, the constraints imposed by contextual and applicative learning media impede educators' capacity to deliver science materials pertinent to environmental concerns (Ramdhan & Hakim, 2025). This is an obstacle in instilling sustainability values through meaningful and interactive learning. Teachers play a pivotal role as learning facilitators, guiding students toward concrete actions that promote a low-carbon lifestyle. Consequently, there is a necessity for the development of additional student-centered learning innovations. These innovations should be designed to foster an interactive learning environment and to support scientific exploration, particularly in the context of environmental awareness. Project-based and contextual learning approaches have been identified as effective strategies to facilitate the connection between science materials and environmental issues that students encounter in their daily lives (Antika, 2014).

Student behaviors that reflect the principle of low carbon still demonstrate a lack of awareness regarding the conservation of energy (Amin et al, 2020a). A number of behaviors and habits among students have been

doi: 10.62672/telad.v3i2.97

ISSN: 2988-2834

identified as contributing to the wasteful use of electrical energy. For instance, 55% of students reported leaving electrical appliances such as cellphone chargers, televisions, and fans plugged into sockets (Amin et al., 2020b). Additionally, 39.6% of students indicated that they frequently leave room lights on even when they are not in use. Furthermore, 49% of students reported leaving air conditioners on for extended periods, with 49% keeping them running for 24 hours (Amin et al., 2020b). Consequently, endeavors to enhance awareness of environmental quality through the adoption of energy-saving behaviors can be facilitated by integrating LCE within an educational setting. This approach endeavors to cultivate sustainable mindsets and habits in society, thereby contributing to environmentally friendly and sustainable development (Warliyah et al., 2023). The objective of this LCE is twofold: first, to reduce energy consumption and pollutant emissions; and second, to raise awareness and cultivate behaviors among students that promote environmental stewardship through daily actions (Hudha et al., 2020).

This community service activity has been identified as a strategic solution for empowering teachers in implementing LCE with a project-based learning approach (Project-Based Learning). This pedagogical approach fosters active student engagement while seamlessly integrating sustainability values into the educational experience (Malay et al., 2025). Teachers will be trained to design and facilitate projects that emphasize energy conservation, waste management, and the use of renewable resources, in accordance with the Independent Curriculum, which emphasizes flexible and exploration-based contextual learning (Yusuf & Arfiansyah, 2021). It is hypothesized that through this activity, teachers will enhance their pedagogical capacity, and students will acquire learning experiences that are relevant, meaningful, and have a positive impact on their environmental awareness and concern.

2. Method

The implementation of this program aims to increase the capacity of teachers in implementing Low Carbon Education (LCE) in learning. The approach used includes training and mentoring, so that teachers can develop low-carbon-based learning tools. This concept aims to instill environmental awareness in students through interactive and applicable learning methods. The transfer of knowledge and technology to teachers is carried out through several stages, including:

2.1. Discussion and Socialization

The discussion and socialization activities began with the presentation of the concept of Low Carbon Education (LCE) as an educational approach that supports climate change mitigation through contextual learning. Furthermore, participants and facilitators identified various environmental problems that occurred in the school environment and discussed strategies for integrating the LCE concept into learning implementation plans (RPP) collaboratively.

2.2. Training on the Preparation of Learning Tools

Teachers participate in training and the development of project-based learning tools that emphasize environmental issues such as energy conservation, the use of alternative energy sources, and waste management. In addition, the creation of learning media that supports students' understanding of climate change and its mitigation efforts

2.3. Mentoring and Evaluation

Teachers are accompanied in implementing the teaching tools of the workshop results in the classroom. Monitoring the effectiveness of low-carbon-based learning and its impact on students' environmental awareness. Evaluation is carried out by pre-test and posttest and reflection on the results of implementation.

The active involvement of teachers greatly determines the success of the program. Therefore, this program emphasizes collaboration between the service team and partners in all stages of implementation. Teachers are not only trainees, but also directly involved in the preparation and implementation of learning tools in the classroom. Through this approach, it is hoped that there will be significant changes in teacher teaching patterns and increased awareness of students' environment, so that LCE can be implemented sustainably in partner schools.

3. Results and Discussion

This activity constitutes the preliminary phase in the design of a teacher empowerment program through the implementation of Low Carbon Education (LCE) in project-based science learning. In addition to its role as a medium for coordination and aggregation, the meeting is also utilized for the purpose of conducting needs assessments concerning material content that is deemed to be contextual and relevant to the learning conditions prevalent at partner schools.

The results of the presentation of socialization materials by the service team at this activity demonstrated that low-carbon education in schools constitutes a component of a global effort through ESD (Education for Sustainable Development) to support the objectives of Sustainable Development Goals (SDGs) 4, namely quality education, and 13, namely action to address climate change. This national policy endeavors to enhance students' cognizance of climate change and promote a culture of low-emission living through tangible actions in educational institutions (Fatimah, 2025). The strategy encompasses the integration of the curriculum, co-curricular, and extracurricular activities, along with the cultivation of energy-saving and environmentally friendly behaviors. The efficacy of this initiative is further bolstered by the implementation of teacher training programs, collaborative efforts with various stakeholders, and the integration of Adiwiyata-oriented initiatives that underscore sustainable practices.

The subsequent material will address the implementation of LCE, which can be achieved through the development of biobattery and bio briquette projects. This innovation has been developed with the objective of reducing waste and promoting the use of cleaner renewable energy sources. Furthermore, the integration of solar cells as a medium for learning, founded on the principles of renewable energy, has been introduced to empower educators in the implementation of LCE. The integration of solar cells in educational settings has been demonstrated to elicit a heightened environmental awareness among students, facilitated by the use of contextual learning methodologies. This integration has been shown to promote a deeper comprehension of clean energy sources and cultivate a sense of responsibility towards mitigating carbon emissions from an early age.

Teacher empowerment through the Pancasila Student Profile Strengthening Project in the Independent Curriculum which is contextual and cross-disciplinary is very important to support sustainable learning. Teachers are encouraged to be active facilitators in designing sustainable learning projects (Hanani et al., 2025), such as the theme of renewable energy and carbon emission reduction (*low carbon education*). Through this approach, teachers in partner schools can increase students' environmental awareness by instilling the value of mutual cooperation, critical reasoning, and concern for local ecological issues directly through real and meaningful activities. The socialization material presentation activity can be seen in Figure 1.

Figure 1. Socialization Material Presentation Activities

Based on the implementation of socialization activities, teachers at partner schools are very enthusiastic about the implementation of the program. The visualization in Figure 2. shows the distribution of teachers based on the subjects they teach.

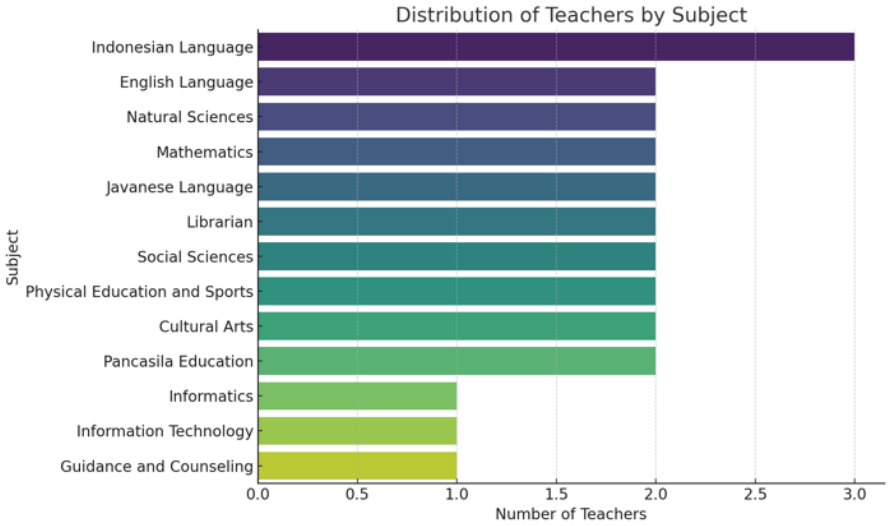

Figure 2. Distribution of Teachers by Subject

The results of the discussion showed that teachers in partner schools were very enthusiastic about welcoming a more applicative, contextual, and oriented approach to environmental issues. The teachers stated that so far students tend to be passive in learning science because the methods used still focus on theory and have not fully related the material to the phenomena around them. Therefore, the integration of local potential in science learning projects is an alternative that is considered very relevant (Sudirman et al., 2024). Some of the environmental issues raised include: waste management (*no littering*, creative recycling), the use of organic waste into compost, energy-saving behavior, and the use of environmentally friendly transportation such as cycling to school.

In terms of pedagogical outcomes, educators express a keen interest in cultivating 21st-century competencies, including critical thinking, digital literacy, and environmental stewardship, through authentic project-based initiatives (Puspitasari et al., 2023). The discussion's outcomes encompassed cognitive dimensions, such as comprehension of pollution and its ramifications, affective dimensions, including heightened environmental consciousness, and psychomotor dimensions, exemplified by the fabrication of recycled products or digital content for environmental campaigns (Susilawati et al., 2025). Teachers also consider the use of simple software to support learning activities, such as image and word processing applications that are easy for students to use (Kusum et al., 2023).

The learning project is planned to be integrated into science learning in 7th grade and 9th grade, with material adjustments. For 7th grade, the teacher proposed the themes of environmental pollution, energy conservation, and the utilization of rudimentary technology. Concurrently, a significant number of 9th grade teachers have expressed interest in integrating social concerns and digital media with environmental initiatives, including social media campaigns promoting low-carbon lifestyles and second-hand upcycling projects. The selection of this material indicates that educators are beginning to adopt a cross-disciplinary and contextual approach in structuring learning.

The discourse further encompassed the prospect of technological integration within educational paradigms, specifically addressing the utilization of Artificial Intelligence (AI). A number of educators have expressed a positive outlook on the potential of artificial intelligence (AI) to enhance digital content creation and learning evaluation. However, some teachers still exhibit reservations due to their limited experience. It is imperative for the implementation team to incorporate digital literacy training and technology exploration as components of teacher empowerment activities. The integration of adaptive, contextual, and technology-based LCE approaches in the classroom learning process is predicated on the assumption that teachers will develop a greater degree of confidence in their abilities to do so. This confidence is expected to be fostered by the provision of continuous training.

4. Conclusion

Community service activities carried out have succeeded in making a real contribution to increasing the capacity of teachers in designing Low Carbon Education (LCE)-based learning. Through intensive training and mentoring, teachers gain an in-depth understanding of LCE concepts as well as project-based contextual learning implementation strategies that emphasize environmental issues and energy-efficient behaviors. The results of the coordination and needs analysis showed that teachers in partner schools had a high enthusiasm in developing learning that was more relevant to the local context and students' lives. This activity also

succeeded in encouraging teachers to start designing science learning projects that integrate local potentials such as waste management, organic waste utilization, and energy efficiency. In addition, this activity also strengthens the role of teachers as facilitators in 21st century learning that is adaptive, interactive, and environmentally friendly.

Author Contributions

All authors have equal contributions to the paper. All the authors have read and approved the final manuscript.

Funding

There is funding support received, namely from the Community Service Research Group Grant (PKM HGR-UNS) in 2025.

Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Acknowledgement

The author would like to thank Universitas Sebelas Maret (UNS) for its funding support through the Community Service Program for Research Group Grants (PKM HGR-UNS) in 2025. This support is very meaningful in the implementation of service activities and the preparation of this article. Gratitude was also conveyed to the activity partners, the school/community, and the entire implementation team who have contributed to the success of this program.

References

Afifah, A. (2021). Peningkatan keterampilan proses sains siswa pada mata pelajaran IPA konsep tekanan zat cair melalui pendekatan STEM (Science Technology Engineering Mathematic) di kelas VIII SMPN 4 Kota Bogor. *Jurnal Pendidikan dan Pengajaran Guru Sekolah Dasar*, *4*(1), 75–79. https://doi.org/10.55215/jppguseda.v4i1.3351

Amin, M. S., Permanasari, A., & Hamidah, I. (2020). Integrasi low carbon education dalam kurikulum pendidikan calon guru IPA di Indonesia sebagai upaya tantangan ekologis di masa depan. *JIPI (Jurnal IPA dan Pembelajaran IPA)*, *4*(2), 231–243. https://doi.org/10.24815/jipi.v4i2.17965

Amin, M. S., Permanasari, A., Setiabudi, A., & Hamidah, I. (2020). Level literasi low carbon siswa sekolah dasar dalam aktivitas kehidupan sehari-hari. *Titian Ilmu: Jurnal Ilmiah Multi Sciences*, *12*(2), 49–57. https://doi.org/10.30599/jti.v12i2.653

Antika, R. R. (2014). Proses pembelajaran berbasis student centered learning (Studi deskriptif di Sekolah Menengah Pertama Islam Baitul 'Izzah, Nganjuk). *BioKultur*, *3*(1), 251.

Fatimah, S. (2025). Dampak perubahan iklim terhadap keberlanjutan hidup di SDN Malaka Sari 04: Tinjauan literatur. *AT-TAKLIM: Jurnal Pendidikan Multidisiplin*, *2*(5), 497–507. https://doi.org/10.71282/at-taklim.v2i5.323

Hanani, S., Ramadhani, S. M., Fiani, R. O., Setiawati, M., & Utama, H. B. (2025). Peran guru dalam menyukseskan implementasi kurikulum merdeka belajar. *Jurnal Intelek Insan Cendikia*, *2*(5), 10622–10628.

Hermanto, F., Sholeh, M., Lukitawati, L., & Saddam, S. (2025). Analisis digital skills peserta didik untuk membangun kemampuan adaptasi terhadap perubahan iklim. *Pendekar: Jurnal Pendidikan Berkarakter*, *8*(1), 55–69.

Hudha, M. N., Hamidah, I., Permanasari, A., Abdullah, A. G., Rachman, I., & Matsumoto, T. (2020). Low carbon education: A review and bibliometric analysis. *European Journal of Educational Research*, *9*(1), 319–329. https://doi.org/10.12973/eu-jer.9.1.319

Kusum, J. W., Akbar, M. R., & Fitrah, M. (2023). *Dimensi media pembelajaran (Teori dan penerapan media pembelajaran pada era revolusi industri 4.0 menuju era society 5.0)*. PT. Sonpedia Publishing Indonesia.

Malay, I., Aulia, A., Utari, D., Meldayani, M., & Falda, S. N. (2025). Analisis model pembelajaran discovery learning untuk meningkatkan pembelajaran pada LCE (Language & Cultural Exchange). *Education Achievement: Journal of Science and Research*, 207–214.

Pursitasari, I. D., Rubini, B., & Suriansyah, M. I. (2023). *Critical thinking & ecoliteracy: Kecakapan abad 21 untuk menunjang sustainable development goals*. Ideas Publishing.

Rahmayanti, H., & Ilyasa, S. K. M. F. (2022). *Pendidikan lingkungan dan perubahan iklim*. Selat Media.

Ramdhan, T. W., & Hakim, Z. (2025). *Desain dan perencanaan pembelajaran* (Vol. 1, No. 1, pp. 1–203). Press STAI Darul Hikmah Bangkalan.

Rozi, F., Ansya, Y. A. U., & Salsabilla, T. (2024). *Strategi pendidikan karakter untuk siswa sekolah dasar dalam mewujudkan tujuan SDG 4: Pendidikan berkualitas*. PT. Penerbit Naga Pustaka.

Sudirman, S., Hardianti, B. D., & Safitri, T. A. (2024). Efektivitas pembelajaran proyek kolaborasi berbasis potensi lokal pada praktikum IPA untuk meningkatkan keterampilan proses sains. *Jurnal Ilmiah Profesi Pendidikan*, *9*(3), 1556–1564. https://doi.org/10.29303/jipp.v9i3.2422

Susilawati, M. P., Puspita, R. D., & Ruqoyyah, S. (2025). *Ekoliterasi: Membentuk calon guru sekolah dasar berwawasan lingkungan*. Indonesia Emas Group.

Warliyah, H., Permanasari, A., Rachman, I., & Matsumoto, T. (2023). Low carbon e-book on climate change with education for sustainable development framework for sustainability literacy of 7th grader. *Jurnal IPA dan Pembelajaran IPA*, *7*(4), 317–334. https://doi.org/10.24815/jipi.v7i4.33663

Yusuf, M., & Arfiansyah, W. (2021). Konsep 'Merdeka Belajar' dalam pandangan filsafat konstruktivisme. *Al-Murabbi: Jurnal Studi Kependidikan dan Keislaman*, *7*(2), 120–133. https://doi.org/10.53627/jam.v7i2.3996