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Training on The Utilization of Organic Waste Into Biobatteries as An Implementation of SDGs in The Merdeka Curriculum for Teachers

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Abstract

The electricity crisis and the rise of organic waste are interconnected environmental issues that also affect education. The Merdeka Curriculum encourages contextual learning by exploring topics like renewable energy and waste management. However, limited practical tools hinder physics teachers in Bandarlampung from delivering SDG-related lessons effectively. This article aims to train physics teachers in creating and using organic waste-based biobatteries, such as those made from banana peels, as learning media. Biobatteries generate eco-friendly electricity and help students understand electrical concepts and sustainability. The training will include tests, discussions, and workshops conducted in an interactive manner. Expected outcomes include improved teacher competence, the creation of innovative practical tools, and publication.

1. INTRODUCTION

The energy crisis has become an important global issue as energy demand increases and dependence on non-renewable resources grows. On the other hand, organic waste scattered throughout the environment shows the low level of public awareness of the importance of sustainable waste management (Awam, *et al.,* 2022). In fact, organic waste has great potential to be processed into environmentally friendly alternative energy*(Alam, et al,* 2024). The imbalance between energy consumption and waste management is a serious challenge in efforts to preserve the environment and community welfare (Logayah*, et al* 2023). The adoption of the Sustainable Development Goals (SDGs) by the global community demonstrates a collective effort to address global challenges as a framework for achieving harmony between environmental sustainability, the economy, and social and political sustainability (Aji & Kartono, 2022). The importance of SDGs in the context of education is particularly reflected in the Merdeka Curriculum.

The Merdeka Curriculum is designed to provide space for students to develop critical understanding of global and local issues, and also equip students with essential skills to face future challenges (Kurniawan, *et al.*, 2024). Contextual learning focuses on the local needs and potential of each region, so this curriculum encourages students to explore various real issues in their environment including the energy crisis and organic waste problems that have not been optimally addressed (Suhartoyo *et al.*, 2020). The increasing depletion of non-renewable energy sources and the large amount of organic waste polluting the environment have encouraged innovation and collective awareness in the search for sustainable solutions. The Medeka curriculum provides space for students to actively participate in scientific projects as solutions, such as the use of organic waste as an alternative energy source (Berliana, *et al.,* 2024) This is expected to shape students into more empowered and broad-minded agents of change in fighting for sustainable development goals(Kurniawan**,** *et al,*. 2024).

Based on preliminary study results, it is known that physics teachers face various obstacles in integrating Sustainable Development Goals (SDGs) concepts into classroom learning (Mardiyanti & Eko, 2020). One of the main obstacles is the limited availability of relevant practical tools that support

teaching SDG issues, especially in topics related to renewable and alternative energy. Materials such as renewable and alternative energy is contextual, practical, and applicable learning approach so that students can gain a deeper understanding and relate theory to everyday reality (Rukoyah, *et al.,* 2025). The absence of appropriate practical tools makes the learning process less effective and less interesting, so that students' potential to develop 21st-century skills, such as critical thinking, creativity, and problem solving, is not optimally trained (Khahro, 2022). SDG issues such as environmentally friendly and affordable energy, responsible consumption and production, and action on climate change are an important part of contextual science learning that is relevant to real life (Martínez-Borreguero, *et al.*, 2024).

In response to this challenge, research was conducted to explore the potential use of organic waste as an alternative energy source through the creation of a biobattery laboratory device. Organic waste, such as fruit peels, vegetables, or certain food scraps, contains natural electrolyte compounds such as organic acids, glucose, and mineral ions that can conduct electricity (Suriana, *et al* ., 2025). For organic waste to be used as a biobattery material, it must have sufficient water content, an appropriate acidity level (pH), and compounds that can act as an electrolyte medium to enable chemical reactions between electrodes (Fatimah, *et al*, 2023), . These contents enable the waste to produce a potential difference when connected to different metal electrodes, such as zinc and carbon (Rahmat, et al., 2023).

This tool is designed not only as an applicable physics learning medium, but also as a means to raise students' awareness of the importance of waste management and environmental sustainability. Through hands-on practice in making and testing biobatteries, students are encouraged to relate scientific concepts to real-world problems in their environment (Raharjo, *et al.,* 2025). This learning not only provides contextual understanding, but also fosters a sense of ecological responsibility and empathy for environmental issues. The results of the study show that the use of biobattery practicum tools can significantly train students' creative thinking skills and encourage them to solve problems in innovative and solution-oriented ways.

Therefore, through this community service, we aim to provide training to physics teachers in

Bandarlampung on the manufacture and use of biobattery practical tools. Our hope is that these teachers will be able to improve their skills in teaching their students about natural disasters and SDGs. We also hope that this training will inspire students to become agents of change who care about the environment and sustainability, and help achieve sustainable development goals locally and globally. Thus, this training is expected to have a positive impact on the Bandarlampung community and make a significant contribution to the overall achievement of the SDGs.

2. METHOD

The method used in this activity is informative, participatory, and applicative. The stages of implementation of this activity include preparation, implementation, and evaluation, as illustrated in Figure 1.

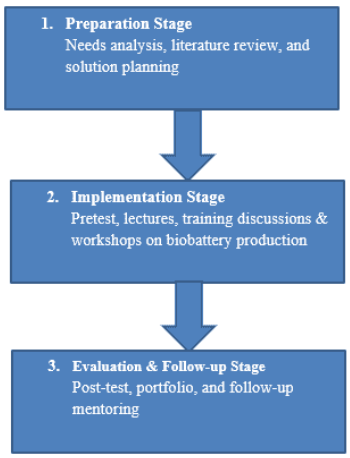

Figure 1. stages of implementation

1. Preparation

At this stage, the research team conducts a needs analysis, literature review, and alternative solution designs for the problems faced by partners.

2. Implementation

3. The implementation stage begins with a pretest to measure the partners' initial knowledge, followed by the delivery of material on the urgency and methods of creating SDG-based learning. In addition, training is provided on how to make physics practicum tools on the topic of alternative energy developed by the Activity Implementation Team. The next stage involves a workshop on the independent creation of simple alternative energy practicum tools, validation of the practicum tools, and presentation of the developed practicum tools.

4. Program Evaluation and Follow-up

3. RESULTS AND DISCUSSION

Results

The community service activity themed “Training on the Utilization of Organic Waste into Biobatteries as an Implementation of SDGs in the Merdeka Curriculum for Teachers in Bandar Lampung” was held on August 16-20, 2025. This activity was divided into two sessions, namely in-service training which took place on August 16 at

Building L, 3rd Floor, Classroom A, and on-service training on August 20, 2025. This activity was attended by 20 science and physics teachers from various schools in Bandar Lampung.

Before the activity was carried out, the community service team sent invitations to physics teachers through the Bandar Lampung City Physics Teacher Working Group to send representatives to participate. Registration was carried out directly at the activity location, without using Google Forms, to make it easier for teachers to register. Once the number of participants reached the specified quota, registration was closed. This activity is part of a faculty grant program that was submitted in May and approved in July 2025.

Activity planning began with a field needs analysis to identify the problems faced by teachers, especially in developing contextual learning media based on environmental issues. The results of this analysis formed the basis for the preparation of activity plans so that the objectives of the community service program could be optimally achieved. The activity was officially opened by Dr. Kartini Herlina, M.Si., representing the community service team and the Physics Education Study Program, Faculty of Teacher Training and Education, University of Lampung.

At the beginning of the training, participants were asked to complete a pretest in the form of essay questions to measure their initial understanding of the concept of organic waste becoming biobatteries in the context of the Merdeka Curriculum and SDGs. The pretest results were used to adjust the material to be delivered. During the activity, the training methods used included lectures, discussions, question and answer sessions, and hands-on practice, with an interactive and enthusiastic atmosphere among the participants.

The first material was presented by Prof. Dr. Abdurrahman, M.Si., who discussed "Utilizing Organic Waste as a Learning Resource." He emphasized the importance of linking physics learning with environmental issues through the use of organic materials such as cassava peel, banana peel, pineapple peel, and dragon fruit peel as learning media. The second material was presented by Dr. Noor Fadiawati, M.Si. with the topic "Utilization of Pineapple Peel Waste as an Alternative to Electricity," which explained the principles of Galvani cells and the application of biobatteries based on natural electrolytes to support science learning based on simple experiments.

Next, Dr. Kartini Herlina, M.Si. delivered a presentation titled "Creativity in Learning," which emphasized the importance of developing the creative thinking skills of teachers and students through problem-solving activities related to organic waste and electrical energy. The final presentation was delivered by Anggreini, S.Pd., M.Pd., who shared best practices for utilizing organic waste to create biobatteries in project-based learning (PjBL) to train 21st-century skills while supporting SDGs 4, 7, 12, and 13.

Overall, this community service activity ran smoothly and received positive responses from participants. Teachers were actively engaged in discussions, asking questions, and participating in the practice of making simple teaching aids from organic waste. Evaluation through pre-tests and post-tests showed an increase in participants' understanding of the concept of biobatteries and their application in learning. This activity successfully fostered teachers' creativity in designing contextual learning, strengthened science literacy, and encouraged the implementation of education for sustainable development (ESD) in schools.

As the author has stated above, one form of assessment is through pre-tests and post-tests. Post-tests are conducted after the presentation of material by all resource persons.

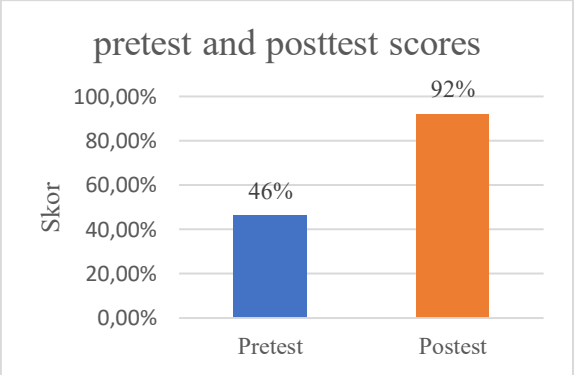

Figure 2. pretest and posttest scores

Based on the results of the data analysis in the table above, it was found that the average pretest score was 46.20% and the posttest score was 92%. These results show an increase of 45.8% after the training and learning activities. This increase illustrates that participants experienced a significant increase in knowledge and understanding after participating in the activities.

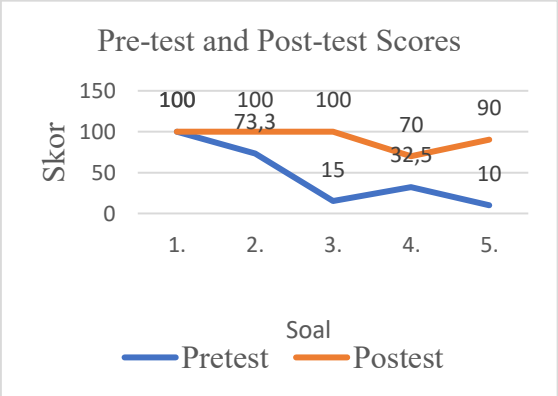

Figure 3. pretest and posttest scores

In detail, the entire range of scores showed a consistent increase from the pretest to the posttest. Most participants

who were initially in the 60–69 and <60 categories successfully moved up to the 80–100 category at the posttest. This proves that the training program implemented was effective in improving participants' learning outcomes and competencies.

Discussion

Based on observations during the training, participants were enthusiastic throughout the activity. During the presentation of material by the presenter, particularly in the discussion and question-and-answer session, participants actively asked questions, expressed their opinions, and shared their teaching experiences related to the use of teaching aids made from organic waste as an application of SDGs in the Merdeka Curriculum at their respective schools. Referring to the opinions expressed by several participants, it was found that basically there was already a desire and even some teachers had implemented various teaching aids to make learning more interesting. However, in general, the implementation was not optimal and some had not even been realized. They face many obstacles, generally related to limited tools and materials, limited funds, and teachers' concerns that they could cause misconceptions if they design the teaching aids incorrectly.

Based on the results of the written test presented in Table 5, it shows that the pretest scores of the biobattery training participants are still relatively low. In general, teachers' understanding of the basic concepts and processes of biobattery production still needs to be improved. From the pretest results, the average achievement of participants was only 46.20%, which shows that most teachers do not yet fully understand the steps and working principles of biobatteries as an environmentally friendly alternative energy source. This condition illustrates that teachers' ability to develop biobattery-based teaching aids is still limited, so more targeted training is needed to improve their competence.

After participating in the training, the post-test results showed a significant improvement, with participants achieving an average score of 92%. This proves that teachers have gained a better understanding of the concept of biobatteries and are able to apply it in a learning context. The improvement in test results shows that the training provided has been effective and has improved teachers' ability to design and create biobattery-based teaching aids.

Overall, this training activity successfully improved the knowledge and skills of science/physics teachers in developing innovative biobattery-based

teaching aids as an application of SDGs in the Merdeka Curriculum. Through this training, teachers became more creative, innovative, and ready to apply environmentally friendly learning media in teaching and learning activities at school. As the author has stated above, the low percentage of participants' success rates in the initial test was due to the fact that most participants did not focus on the training on making teaching aids from electronic waste as an application of SDGs in the Merdeka Curriculum. This condition provides us with information about the knowledge and understanding of science or physics teachers regarding the making of teaching aids from electronic waste as an application of SDGs in the Merdeka Curriculum.

Teachers' understanding of making teaching aids from electronic waste as an application of SDGs in the Merdeka Curriculum increased after participating in the training. This can be seen from the post-test answers of the training participants, where almost all teachers answered correctly. Teachers' perception of making teaching aids from electronic waste as an application of SDGs in the Merdeka Curriculum is no longer difficult. This can actually be utilized in learning innovation efforts that make use of items around students.

4. CONCLUSION

The community service activity themed "Utilization of Organic Waste into Biobatteries as Implementation of SDGs in the Merdeka Curriculum" succeeded in improving the knowledge and skills of science and physics teachers in developing environment-based learning media. The evaluation results showed a significant increase between the pretest and posttest scores, indicating an increase in participants' understanding of the concept of biobatteries and the application of SDGs in learning. Overall, this activity was effective in fostering creativity, innovation, and teachers' awareness of the importance of sustainable education in accordance with the principles of Education for Sustainable Development (ESD).

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It is hoped that the results of this training activity will provide tangible benefits in improving the

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