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Improving Teacher Competence through SDGS-Based Learning Design Training: A Practice-Based Approach Using Black Soldier Fly Cultivation

Ulfi Faizah [1*], Muji Sri Prastiwi[2], Nur Ainiyah[3], Walib Abdullah[4]
Dian Permatasari Kusuma Dayu[5], Dwi Setyo Pratiwi[6]

[1,2,3,4,5,6]Universitas Negeri Surabaya
Indonesia
[✉]ulfifaizah@unesa.ac.id[*]

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Abstract

Background: Teachers at Insan Cendekia Mandiri Boarding School, Sidoarjo, needed the initiative to bridge the gap between theory and practice. We knew that educators need more than just concepts, so we provide hands-on training to help them design SDG-based lessons that effectively instill sustainability values directly in the classroom.
Objectives: This community service program aimed to improving teacher competence through SDGs-based learning design training: a practice-based approach using black soldier fly cultivation. Teachers at Insan Cendekia Mandiri Boarding School, Sidoarjo empowered through a workshop on SDG-based lesson design with essential sustainability values.
Methods: This community service activity was conducted through a workshop-based approach. The program began with an introduction to SDG-based learning models and methods, followed by the development of relevant teaching materials and media. It also included hands-on workshops and learning simulations using black soldier fly cultivation, concluding with continuous evaluation and long-term mentorship.
Result: The program successfully empowered the teachers through three core achievements: a deeper understanding of SDG-based design and black soldier fly cultivation proven by improved test scores; a wealth of innovative strategies for the curriculum; and the practical skills to bring these lessons to life. The teachers' enthusiastic response reflected a newfound confidence in leading sustainable learning.
Conclusion: This community service program has successfully improving teacher competence through SDGs-based learning design training with a practice-based approach using black soldier fly cultivation empowered teachers at Insan Cendekia Mandiri Boarding School, Sidoarjo. Through specialized training in SDG-based lesson design, we have equipped educators with the tools and knowledge needed to share essential sustainability values with their students.

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A. Introduction

A strategic way to create high-quality learning that meets 21st-century challenges is to integrate the Sustainable Development Goals (SDGs) into education. Guided by the Education for Sustainable Development (ESD) framework, learning focuses on knowledge and on fostering the values and critical thinking skills needed for a sustainable future (Sachs et al., 2022; UNESCO, 2020) .Research in international studies proved that contextual, experience-based SDG learning effectively boosts student engagement and awareness (Ho et al., 2022; Huang et al., 2024; Žalėnienė & Pereira, 2021). SDG education in Indonesia is growing, teachers still need more support in designing systematic and practical lesson plans (Faizah & Nugraheni, 2024; Lestari et al., 2024). Several research studies on teachers' Education for Sustainable Development (ESD) abilities have found a favorable understanding and attitude toward sustainability problems. Teachers' ESD competences may be assessed based on their knowledge, skills, attitudes, and pedagogical abilities in integrating sustainable ideals into instruction (Brandt et al., 2022; García-Fortes et al., 2024). This indicates the necessity of the implementation of SDGs and ESD-related education in schools.

Successful integration depends on a teacher's ability to design and evaluate sustainability-based lessons. Today, teachers need to master "sustainability competencies," such as systems thinking and value-based decision-making (Annelin & Boström, 2023; Husamah et al., 2022; Redman & Wiek, 2021). Effective professional development must be ongoing and practice-based to real transform the classroom (Borko et al., 2019; Desimone & Garet, 2015; Korthagen & Nuijten, 2022). To improve the knowledge, abilities, and methods of sustainability-based contextual learning, ESD competence development for educators has been carried out in connection with continuing professional development (AlAfnan & Dishari, 2024; Susanti et al., 2024). But the application of ESD-based learning is still not at its best, especially when it comes to transformative pedagogy, teamwork, and practical problem-solving (Brandt et al., 2022; García-Fortes et al., 2024). This suggests a **theoretical and research gap** in the integration of sustainability competency theory and transformational educational frameworks for contextual and practice-based ESD implementation.

When many Indonesian educators still have gaps in designing SDG tools, community service programs like workshops and mentorship are essential interventions to strengthen their professional skills (Faizah et al., 2024; Suttrisno & Yulia, 2022; Taimur & Sattar, 2020). Many community programs have successfully used context-based training to improve teaching skills, from educational games to innovative media (AR et al., 2023; Hapudin & Mujazi, 2024; Medriati et al., 2023; Murron et al., 2024). Training about real-world environmental issues and sustainability also makes learning more meaningful (Eliyawati et al., 2023; Fata et al., 2020). However, most programs still focus on manual or traditional skills rather than a systematic SDG framework. (Samsilayurni et al., 2024; Werang et al., 2024). To reduce the gap, some workshop and mentorship programs offers a "state-of-the-art" approach to strengthen teacher competence sustainably.

Insan Cendekia Mandiri Boarding School (ICMBS) consists of several education levels with an integrated curriculum designed to raise world-class leaders. Research suggests that systematic SDG-oriented planning is a way to teacher professionalism and student well-being (Lase, 2022; Lestari et al., 2024; Ponce et al., 2023). **The problem** was that teachers received limited practice-based training related to the SDGs. Thus, this practice-based mentorship is a key solution to help ICMBS teachers integrate SDGs meaningfully into subjects.

The Biology Education team from Universitas Negeri Surabaya conducted a workshop on "SDG-Based Lesson Design" for ICMBS teachers to meet the need. This community service program aimed to improving teacher competence through SDGs-based learning design training: a practice-based approach using black soldier fly cultivation. Teachers at Insan Cendekia Mandiri Boarding School, Sidoarjo empowered through a workshop on SDG-based lesson design with essential sustainability values. **The objective** was to deepen understanding of sustainability, introduce innovative learning strategies, and help teachers compile relevant teaching materials. This activity was a follow-up to address the shortcomings of earlier SDG training programs, which mostly concentrated on using maggot cultivation to accomplish SDG 12. **The novelty** of this program was combining SDG lesson design with hands-on maggot (*Black Soldier Fly*) cultivation. This unique approach bridges the gap between theory and practice by using organic waste management as a real-world classroom activity.

B. Methods

The time of this activity was carried out in the odd semester of 2025/2026, and **the places** were the Biology Education Undergraduate Program campus, Faculty of Mathematics and Natural Sciences, Unesa Ketintang, Surabaya, and Insan Cendekia Mandiri Boarding School (ICMBS), Sidoarjo. **The population** of the service program: Teachers at ICMBS, Sidoarjo. **The respondents** included 15 junior high school teachers and 14 high school teachers. **The methods** of the community service program use a participatory workshop model designed around four key steps: understanding, observation and instruction, instructional practice, and reflection **(Figure 1).** The program aimed to boost teacher competency in designing lessons rooted in Sustainable Development Goals (SDGs) and sustainability values. By blending pedagogical strength with local context, it offers a hands-on experience—integrating maggot cultivation (*Black Soldier Fly*) as a practical, real-world learning activity.

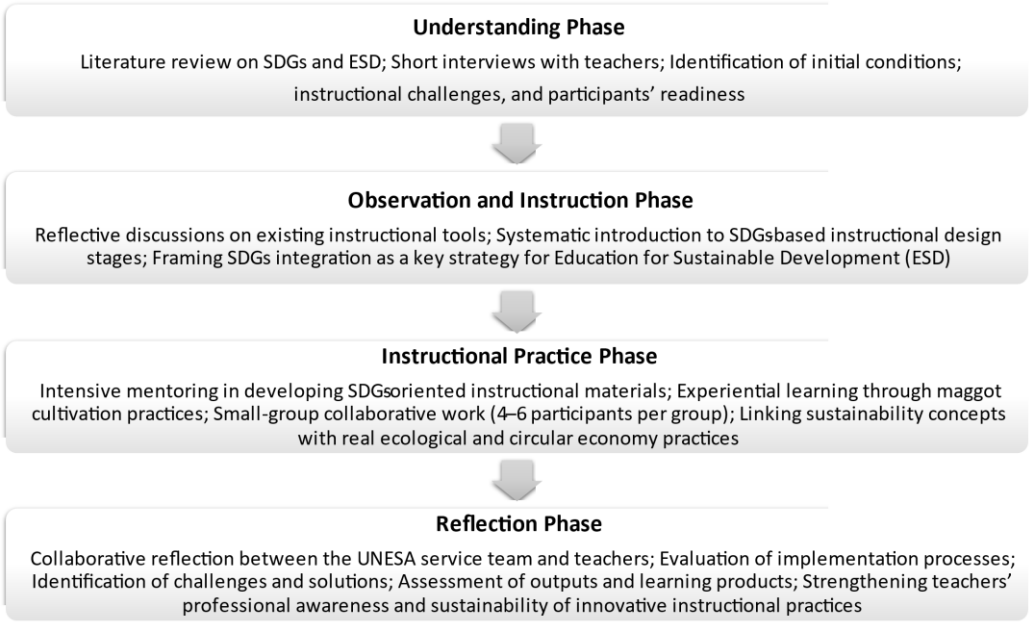

Figure 1. The Procedure of Community Service Program

The instrumentation and analysis method are explained in the following Table 1. Expert judgment was used in instrument validation to determine if the instrument is appropriate for the activity under evaluation. Despite its systematic design, this program has **limitations**. The needs analysis was preliminary, and due to time constraints, the lesson plans remain at a prototype stage without a formal follow-up mechanism. Additionally, as the workshop offered only a brief look at maggot cultivation, its long-term impact on classroom teaching practices has yet to be fully evaluated.

Table 1. Objectives, Data Sources, Instruments, and Analysis of the Community Service Program

No.	Community Service Program Objective	Data	Instrument	Analysis Method
1	Provide a comprehensive understanding of sustainability concepts.	Teachers' understanding scores	Pretest–posttest questionnaire	Descriptive analysis
2	Provide innovative and contextual teaching strategies.	Teachers' responses and perceptions	Response questionnaire	Descriptive analysis
3	Support teachers in developing relevant teaching modules.	Quality of instructional modules	Assessment rubric	Descriptive analysis

C. Results and Discussion

1. Results

Nowadays, SDGs are a crucial component of many facets of life, including education.Teachers must have skill in designing SDG-based lessons to instill sustainability values in their students. This community service program specifically highlights SDG 12: Responsible Consumption and Production, utilizing maggot cultivation (Black Soldier Fly/BSF larvae) as a practical solution for organic waste management. The program was conducted in two sessions.

The first session (Figure 2) on Wednesday, August 13, 2025, featuring two presentations by the community service program team. The first topic, **Designing SDG-Based Learning to instill Sustainability Values**, was presented by the first keynote speaker. During this session, teachers were guided in creating teaching modules that integrate sustainability values. These modules generally include learning objectives, classroom activities, and assessment plans. The sustainability values as ESD competencies emphasized included critical thinking, anticipatory and normative skills, strategic thinking, collaboration, self-awareness, and integrated problem-solving.

The second session, about **Maggot Cultivation in Education: Educational Strategies to Support SDG 12**, was presented by the second keynote speaker. He explained that BSF maggots (*Hermetia illucens*) have a life cycle consisting of five stages: egg, larva (maggot), prepupa, pupa, and imago (adult fly). maggot cultivation involves breeding these larvae in a controlled environment through four key steps: 1) Preparation and Egg Hatching, 2) Larval Rearing, 3) Harvesting, and 4) BSF Colony Management to continue the reproductive cycle. At the end of the first session, 26 participants were given a group assignment by the team. They practiced maggot cultivation using provided kits over four weeks. For the individual task, each teacher was also tasked with developing a teaching module that integrated sustainability values relevant to their specific subject.

The second session (Figure 3) was held on Wednesday, September 10, 2025, with a focus on showcasing their instructional modules and cultivation outcomes. Even if fungal and ant problems meant that the output was not yet at its peak. The teachers' skillful handling of the life cycle from egg to egg was evident throughout the presentations. This first experience motivated them to monitor the environment more closely in their later farming pursuits. The instructors collaborated to construct four educational modules. The module presentations were given by a junior high and senior high informatics instructor.

Figure 2. The first session of the Community Service Program

Figure 3. The second of the Community Service Program

Results of Participants' Comprehensive Understanding of the Concept of Sustainability Based on Pre-test and Post-test Results

The participants' comprehensive understanding of sustainability was indicated by post-test scores that significantly surpassed pre-test results, with a minimum score of 76. The program positively impacted the teachers' knowledge across all training materials from SDG integration and Project-Based Learning (PjBL) to the Profil Pelajar Pancasila and maggot (BSF) cultivation. Pre-test scores gave information that moderate-to-high prior knowledge (63–92%); the post-test demonstrated consistent growth, reaching 91–100% across nearly all indicators. Notably, over 90% of participants correctly answered 9 out of 10 questions, with the highest gains seen in the relevance of PjBL and BSF-based contextual learning. These findings confirm that active, experience-based learning was an effective approach for sustainable education.

The pre-test to post-test improvement showed a moderate-to-high N-gain, particularly in areas such as BSF safety and site selection that previously had lower scores. This improvement indicates that practice-based training effectively bridges the gap between theory and real-world application, consistent with studies highlighting the effectiveness of experiential professional development and maggot cultivation as an educational medium for environmental sustainability and SDG learning (Brandt et al., 2022; Desimone & Garet, 2015). Ultimately, the program not only improved cognitive outcomes but also strengthened teachers' professional readiness to implement systematic and value-oriented SDG learning in their classrooms.

Results of Maggot Cultivation Practices and Results of relevant and applicable learning devices created by teachers

The teachers as participants can put their knowledge into practice by managing the full life cycle from larvae to breeding adult flies-after learning about maggot cultivation. This hands-on activity demonstrated the maggots' effectiveness in decomposing organic waste (Figure 2). The participants also refined their existing teaching materials to be more relevant and practical. Consequently (Figure 3).

Figure 4. Results of Maggot Cultivation

Figure 5. Results of the Developed Teaching Modules

The educators effectively created SDG-based educational resources that include fundamental sustainability principles. Education for Sustainable Development (ESD) competencies generally include a set of knowledge, skills, values, attitudes, and abilities to act that enable individuals to contribute to sustainable development. ESD competencies consist of: Systems Thinking Competency: The ability to understand the relationships between components in a complex system, including the interrelationships of environmental, social, and economic aspects; Anticipatory Competency: The ability to predict and evaluate future possibilities and the impact of decisions on sustainability; Normative Competency: The ability to understand and reflect on values, ethics, and principles of sustainability in decision-making; Strategic Competency: The ability to design and implement concrete strategies or actions to achieve sustainability goals; Collaboration Competency: The ability to collaborate, communicate, and participate effectively with various parties; Critical Thinking Competency: The ability to critically analyze problems, evaluate assumptions, and reflect on various perspectives; Self-awareness Competency: The ability to understand

one's role, personal values, and individual responsibilities towards sustainability; Integrated Problem-Solving Competency: The ability to integrate various approaches and competencies to solve sustainability problems contextually (Brundiers et al., 2020; UNESCO, 2017). Four samples of the final modules are shown below, along with descriptions of the SDGs they cover (Table 2).

Table 2. Examples of SDGs-Integrated Teaching Modules Developed by Teachers

No	Subject and Grade	Learning Focus	Learning Objectives	SDGs-Related Competencies
1	Informatics (Grade IX, JHS)	Digital content using Book Creator	Students design and present digital flipbooks on conserving local plant species	Creativity, critical thinking, collaboration, communication
2	Indonesian Language (Grade VIII, JHS)	Acrostic poetry	Students compose sustainability-themed poems and present them as environmental literacy campaigns	Critical reasoning, creativity, collaboration, communication
3	Mathematics (Grade IX, JHS)	Data presentation and mean calculation	Students analyze environmental issues using diagrams and spreadsheet data	Creativity, cooperation, learner autonomy
4	Biology (Grade X, SHS)	Protist observation	Students classify organisms and observe protists through simple experiments	Critical thinking, collaboration, problem-solving

The teaching modules produced by the teachers were evaluated using six SDG-related assessment criteria with particular indications. Table 3 provides a full summary of the evaluation outcomes.

Table 3. Assessment Results of Teaching Module Products

No	Aspect Assessed	Indicator	Average Score	Interpretation
1	Integration of sustainability values	Explicit inclusion of environmental, social, and/or economic dimensions	4	Good
2	Contextual relevance	Learning materials linked to real-world contexts	4	Good
3	Alignment with SDGs	Learning objectives aligned with at least one relevant SDGs target	3	Moderate
4	Instructional strategy innovation	Use of active learning approaches (PjBL, inquiry, problem-based learning)	3	Moderate
5	Feasibility	Modules can be realistically implemented in school contexts	3	Moderate
6	Clarity and organization	Logical structure, clear language, and ease of understanding	3	Moderate

The teaching modules produced in Table 3 demonstrate that the training effectively encourages the integration of SDGs across subjects, including informatics, Indonesian language, mathematics, and biology. These modules emphasize 21st-century skills such as creativity, critical thinking, and problem-solving by linking curriculum content to real-world issues like local plant conservation and environmental literacy through maggot-themed poetry. This cross-disciplinary approach aligns with literature suggesting that contextual SDG-based learning effectively builds sustainability competencies in students (Faizah & Nugraheni, 2024; Ponce et al., 2023; UNESCO, 2020).

Assessment results indicate high scores in integrating environmental, social, and economic dimensions within a real-world context. While innovative strategies like Project-Based Learning (PjBL) are being implemented, further mentorship is needed to fully refine these systematic designs. These findings remain consistent with studies highlighting that practice-based professional development is crucial for enhancing

teacher readiness to implement value-oriented sustainability lessons (Borko et al., 2019; Desimone & Garet, 2015; Faizah et al., 2024; Lase, 2022).

Results of participants' responses to training activities

The participants found the training to be extremely relevant to school requirements, according to the questionnaire answers, which show a very good reaction. The successful integration of SDGs through maggot cultivation increased teacher engagement and environmental knowledge, confirming research that indicates active, contextual methods enhance professional awareness and sustainability capabilities (Faizah & Nugraheni, 2024; Ponce et al., 2023; UNESCO, 2020).

Participants also highly rated the clear delivery and supportive atmosphere, noting that it significantly expanded their professional insights. Despite minor suggestions for more practice time, the program followed effective professional development principles: relevance, collaboration, and reflective practice (Borko et al., 2019; Desimone & Garet, 2015). Ultimately, this initiative created a meaningful learning experience that empowers teachers to implement sustainable SDG-based education (Faizah et al., 2024; Lase, 2022).

2. Discussion

2.1 Implications

The community service program at Insan Cendekia Mandiri Boarding School drives a pedagogical shift from content-oriented methods to contextual learning that instills sustainability values. By integrating global SDG issues into lessons that resonate with students' real-world experiences, teachers reinforce the school's role as a key agent for Education for Sustainable Development (UNESCO, 2020). This reflective and collaborative workshop model enhances professional capacity and confidence, proving that experience-based development is far more effective than purely instructional training (Desimone & Garet, 2015; Korthagen & Nuijten, 2022).

At the institutional level, the program provides a replicable model and evaluation instruments for SDG-based learning, particularly suited for the holistic character building of boarding schools. Beyond improving individual teacher competency, this initiative strengthens school culture and supports sustainable education policies aligned with the global development agenda (Sachs et al., 2022). These efforts ensure that educators are better prepared to implement sustainability values across various subjects.

2.2 Research contribution

This community service program offers significant theoretical and practical contributions to teacher professional development and the implementation of Education for Sustainable Development (ESD). Theoretically, it enriches the study of teacher training by presenting a reflective workshop model that demonstrates how the SDGs can be systematically translated into contextual and applicable lesson designs (Desimone & Garet, 2015; UNESCO, 2020). Empirically, this initiative provides evidence that experiential and collaborative learning including the use of maggot cultivation effectively enhances a teacher's ability to create innovative instructional tools that integrate sustainability values (Kolb, 2014). Practically, the program has produced SDG-based lesson plans and evaluation rubrics that can be replicated in other schools. This serves as an implementable model for strengthening ESD, particularly within boarding school environments that possess great potential for holistic value-based learning (Korthagen & Nuijten, 2022).

2.3 Limitations

This workshop-based community service program had several limitations, including a preliminary needs analysis based only on literature reviews and brief interviews, limited time that resulted in learning tools remaining at the prototype stage, and the absence of follow-up monitoring for classroom implementation. In addition, the maggot cultivation practices conducted during the workshop did not fully reflect long-term school implementation, making it difficult to comprehensively evaluate changes in teachers' teaching practices. These limitations were likely influenced by the short duration of the program, whereas effective

teacher training and evaluation require continuous needs assessment and sufficient time for measuring instructional change (Desimone & Garet, 2015; Kolb, 2014).

2.4 Suggestions

In summary, the primary limitations of this program lie in its duration, the depth of the initial needs assessment, and the current lack of long-term impact evaluation. These challenges, however, present valuable opportunities for growth in future initiatives. Moving forward, the Unesa team hopes that teachers will continue to apply and refine their sustainability-based modules while maintaining maggot cultivation efforts to support the global achievement of the SDGs. Continuous reflection and follow-up mentoring over an appropriate period of time will be more effective in encouraging transformation in teacher professional practice (Korthagen & Nuijten, 2022).

D. Conclusion

This community service program has successfully improving teacher competence through SDGs-based learning design training with a practice-based approach using black soldier fly cultivation. The participating teachers have gained a comprehensive understanding of sustainability concepts, acquired innovative and alternative teaching strategies, and are now capable of developing relevant and practical teaching materials.

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F. Author Contribution Statement

All team members contributed to the planning, implementation, and completion of this community service activity. The team collaboratively developed the initial concept and design of the training program. UF and MSP were responsible for communication and coordination with Insan Cendekia Mandiri Boarding School (ICMBS), Sidoarjo, regarding the implementation of the training and preparing training materials. NA and WA were responsible for organizing the implementation of the training activities and guiding the maggot cultivation activities, as well as conducting documentation. DPKD and DSP were responsible for administering the activities, preparing pre- and post-tests, and ensuring the smooth running of Community Service Program data collection. All team members were involved in data analysis and interpretation of findings, as well as drafting the article.

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