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Fostering Data Literacy and Environmental Awareness among Students through Statistics Education at SMAN 1 Sipoholon

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ABSTRACT
Data literacy and environmental awareness are essential competencies for students in responding to contemporary social and environmental challenges. However, the integration of statistical education with real-life environmental contexts remains limited in many secondary schools. This community service program aimed to foster data literacy and environmental awareness among students at SMAN 1 Sipoholon through statistics-based educational activities. The program was conducted on 10 October 2025 and involved 25 participants consisting of students, internal participants, organizers, and a resource person. The implementation was carried out through two main stages: (1) training and capacity building in basic statistical concepts, and (2) reward-based question-and-answer activities to reinforce learning outcomes. Data were collected using pre- and post-activity questionnaires, observation sheets, and analysis of student responses during interactive sessions. The results indicate an improvement in students' understanding of basic statistical concepts, increased engagement during learning activities, and enhanced awareness of the role of data in interpreting environmental issues. Positive responses from teachers and students highlight the effectiveness of contextual and participatory learning approaches supported by lecturer and university student mentoring. Despite limitations related to time and learning resources, the program demonstrated promising outcomes and offers a replicable model for similar educational contexts. This community service initiative contributes to the promotion of quality education and environmental awareness in alignment with the Sustainable Development Goals (SDGs).

Keyword: Data Literacy, Statistics Education, Environmental Awareness

1. Introduction

In the era of data-driven decision making, data literacy has become a fundamental competency for students, particularly in responding to complex social and environmental challenges. Statistical education plays a crucial role in developing students' ability to collect, analyze, interpret, and utilize data meaningfully. At the same time, environmental issues such as waste management, climate change, and ecosystem degradation demand a generation that is not only aware but also capable of understanding environmental phenomena through data-based reasoning [1]. Therefore, integrating statistics education with environmental awareness is an important strategy to prepare students as part of the future golden generation.

SMA Negeri 1 Sipoholon, located in North Tapanuli, represents an educational environment with strong potential for the development of data literacy and environmental awareness among students. However, preliminary observations indicate that students' exposure to applied statistics remains limited, particularly in connecting statistical concepts to real-life environmental contexts [2]. Statistics is often perceived as an

abstract subject, detached from daily experiences, which reduces students' interest and limits its practical impact on shaping critical and environmentally responsible thinking.

Figure 1. SMA Negeri 1 Sipoholon

To address this situation, a Community Service Program (Pengabdian Kepada Masyarakat/PKM) was conducted at SMA Negeri 1 Sipoholon on 10 October 2025. The activity involved 25 participants, consisting of 15 members of the school community (students), 6 internal participants, 3 organizing committee members, and 1 main resource person. The program focused on introducing basic statistical concepts through contextual learning activities that relate data analysis to environmental issues familiar to students' surroundings. One of the main challenges faced by the partner institution is the lack of structured learning activities that integrate statistics with contextual environmental problems. Limited access to learning resources, insufficient practice-oriented statistical materials, and minimal collaboration between schools and higher education institutions further contribute to this gap. As a result, students have not yet fully developed the ability to interpret environmental data critically or use statistical reasoning as a tool for understanding real-world issues [3].

This community service initiative is closely aligned with the Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education), which emphasizes inclusive and equitable education, and SDG 13 (Climate Action), which highlights the importance of education in addressing environmental challenges. By strengthening students' data literacy through statistics education, this program contributes to building capacities necessary for sustainable development at the local level [4]. In addition, the program addressed unique challenges specific to the Sipoholon area that remain unresolved, such as limited student engagement with local environmental data and the absence of data-based environmental awareness programs in schools. These challenges highlight the urgent need for educational interventions that connect statistical learning with local environmental contexts.

This article aims to analyze the implementation and impact of statistics-based educational activities in fostering data literacy and environmental awareness among students at SMA Negeri 1 Sipoholon. The program actively involved lecturers and university students in mentoring and guiding high school students, creating a collaborative learning environment that bridges higher education and secondary education [5]. Through this engagement, students were introduced to the importance of statistics as a practical tool for understanding environmental issues and making informed decisions, thereby strengthening their critical thinking and social responsibility.

2. Methods

This study employed a community service–based educational approach using a participatory and educational intervention design. The methodology was structured to strengthen students' data literacy and environmental awareness through applied statistics education. The implementation followed a systematic and chronological sequence, ensuring that all stages from preparation to evaluation were clearly defined and measurable. The

community service program was conducted at SMAN 1 Sipoholon and involved active collaboration between lecturers, university students, teachers, and high school students. The methodological framework emphasized interaction, contextual learning, and reflective evaluation to assess the effectiveness of the intervention.

2.1. Implementation Stages of the Community Service Program

The implementation of this community service activity was carried out through two major stages, as follows:

Stage 1: Training and Capacity Building in Statistics

The first stage focused on training and enhancing human resource capacity (SDM) in the field of statistics. This stage aimed to introduce students to the fundamental concepts of statistics and their relevance to environmental issues encountered in daily life [6].

At this stage, the following methods were applied:

1) Material Preparation
   Information was compiled from textbooks, national curricula, and relevant statistical references to design training materials that met the specific needs of the partner institution. The materials emphasized basic data concepts, simple data analysis, and real-life environmental applications.
2) Observation and Needs Assessment
   Observations and discussions were conducted with teachers and students to identify existing challenges, learning gaps, and local environmental contexts. This process helped map students' initial understanding, learning motivation, and potential areas for development, particularly in fostering creativity and active participation.
3) Interactive Statistical Training
4) The training sessions were delivered using interactive learning strategies such as contextual examples, guided discussions, and simple data interpretation exercises. The learning activities were designed to broaden students' perspectives on the role of statistics in environmental problem-solving and its relevance to future career opportunities, supporting the vision of Indonesia Emas.

Stage 2: Reward-Based Question and Answer Sessions

The second stage aimed to reinforce learning outcomes through reward-based question-and-answer activities. This stage served as both a learning reinforcement mechanism and an informal evaluation tool [7].

Students were invited to answer questions related to:

- Basic statistical concepts introduced during the training
- Interpretation of simple data
- The role of statistics in understanding environmental issues

Reward incentives were provided to encourage active participation, boost student motivation, and create a positive learning atmosphere. This approach helped ensure that students were not only passive recipients of information but also active contributors to the learning process.

2.2. Instruments and Measurement of Success

To evaluate the effectiveness of the community service program, several measurement instruments were employed:

1) Pre-Activity and Post-Activity Questionnaires
   Questionnaires were administered before and after the program to assess changes in students' data literacy and environmental awareness. The questionnaires focused on basic understanding of statistics, attitudes toward data usage, and awareness of environmental issues.
2) Observation Sheets
   Structured observation sheets were used to document student engagement, participation levels, and interaction during training and discussion sessions.
3) Response Accuracy in Reward-Based Questions
   The accuracy and quality of student responses during the reward-based sessions were recorded as indicators of conceptual understanding and learning improvement.

The collected data were analyzed using descriptive statistical techniques. Pre-test and post-test questionnaire results were compared using percentage improvements and mean score differences to identify learning gains. Observational data were analyzed qualitatively to capture patterns of student engagement and behavioral

changes during the activity [8]. This combined quantitative–qualitative analysis provided a comprehensive evaluation of the program's effectiveness in fostering data literacy and environmental awareness among students.

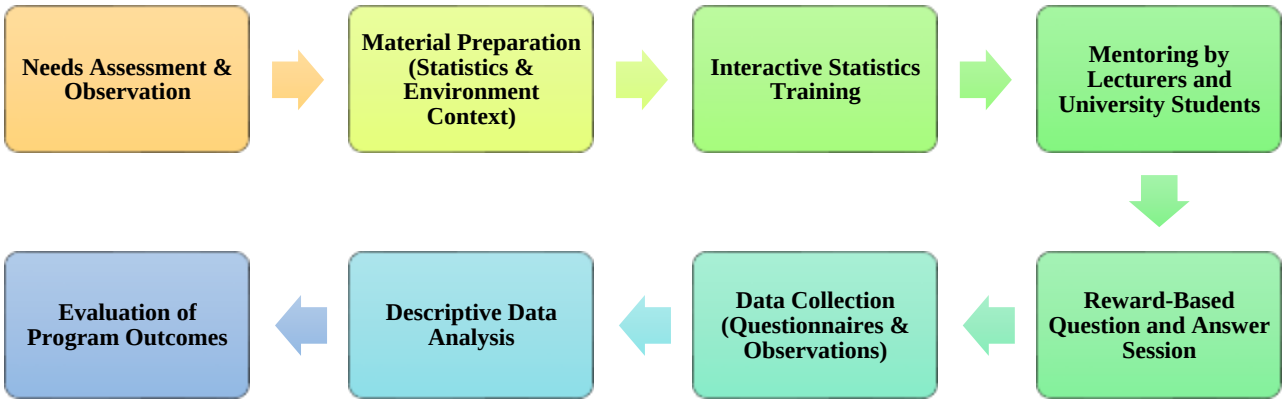

Figure 2. Implementation Framework

3. Result and Discussion

The results of the community service program indicate a positive improvement in students' data literacy and environmental awareness after participating in the statistics-based educational activities. Based on the pre-activity questionnaires, most students demonstrated limited understanding of basic statistical concepts and showed minimal awareness of how data could be used to analyze environmental issues in their surrounding areas. Following the implementation of the training and interactive activities, post-activity questionnaire results revealed a noticeable increase in students' understanding of fundamental statistics, such as data interpretation, basic categorization, and simple graphical analysis. Students also showed a stronger awareness of the role of data in identifying and understanding environmental problems, particularly those related to waste management and local environmental conditions. This improvement suggests that contextualized statistics education can effectively bridge the gap between abstract mathematical concepts and real-life environmental challenges.

Figure 3. Introduction and Opening Session of the Community Service Program at SMAN 1 Sipoholon

Observational data collected during the training sessions showed a significant increase in student engagement. During the initial sessions, student participation was relatively passive, with limited interaction and questioning. However, as the training progressed especially during contextual examples and guided discussions students became more active in sharing opinions and responding to questions. The reward-based question-and-answer session further reinforced learning outcomes.

Figure 4. Interactive Statistics Training Session on Data Literacy and Environmental Awareness

Students demonstrated higher confidence in answering statistical questions and were able to articulate the relevance of statistics to environmental issues. The accuracy of student responses during this session served as an additional indicator of improved conceptual understanding, supporting the quantitative findings from the questionnaire results.

The impact of this community service activity extended beyond individual learning outcomes. From the partner institution's perspective, teachers and school representatives expressed positive responses toward the integration of statistics with environmental contexts. They observed that students were more motivated and attentive when statistical concepts were presented through practical and locally relevant examples. Moreover, the involvement of lecturers and university students as mentors created a collaborative learning atmosphere that strengthened connections between higher education institutions and secondary schools. This mentorship model was perceived by the partner as an effective approach to enriching classroom experiences and introducing students to broader academic and career perspectives related to statistics and data science.

Figure 5. Student Discussion and Mentoring Activities during Statistics Education Sessions

Despite the positive outcomes, several challenges were identified during the implementation of the program. One major challenge was the limited time allocation for training activities, which restricted deeper exploration of statistical tools and more comprehensive hands-on practice. In addition, variations in students' prior knowledge required facilitators to continuously adjust the pace and depth of material delivery. Another challenge involved limited access to supporting learning resources, such as digital tools for data visualization, which could further enhance students' learning experiences. These constraints highlight the need for more sustained and resource-supported interventions in future implementations.

Figure 6. Reward-Based Question and Answer Session to Reinforce Statistical Concepts

To ensure sustainability, this community service program emphasizes the importance of follow-up activities and long-term collaboration between universities and schools. Teachers are encouraged to integrate contextual statistical examples into regular classroom instruction, particularly by using local environmental data as learning materials.

Figure 7. Group Photo of Participants and Facilitators at the End of the Community Service Program

Furthermore, the program model developed through this activity can be replicated in other schools with similar characteristics, contributing to broader efforts aligned with the Sustainable Development Goals (SDGs), especially quality education and environmental awareness. Continued involvement of lecturers and university students in mentoring roles is expected to strengthen the long-term impact of statistics education in fostering data-literate and environmentally conscious students.

4. Conclusion

This community service program demonstrates that statistics-based education can effectively foster data literacy and environmental awareness among students at SMAN 1 Sipoholon. Through a structured and contextual learning approach, students were able to develop a better understanding of fundamental statistical concepts and recognize the relevance of data in interpreting environmental phenomena in their daily lives. The integration of statistics with real-world environmental contexts successfully transformed abstract mathematical ideas into meaningful and applicable knowledge. The implementation of interactive training sessions, supported by mentoring from lecturers and university students, played a significant role in increasing student engagement and learning motivation. The reward-based question-and-answer activities further reinforced students' understanding and encouraged active participation, contributing to measurable improvements in learning outcomes. These findings highlight the importance of participatory and experience-based learning methods in strengthening students' cognitive and affective competencies.

From the partner institution's perspective, the program provided added value by introducing an innovative learning model that aligns statistical education with environmental awareness. Positive responses from teachers and students indicate that such an approach can enhance classroom dynamics and support the development of critical thinking skills. Moreover, the collaboration between higher education institutions and secondary schools proved to be an effective strategy for expanding educational impact beyond formal curricula. Despite limitations related to time allocation and resource availability, the program achieved its primary objectives and offers a replicable framework for similar community service initiatives in other educational settings. To ensure sustainability, continued integration of contextual statistics into school curricula and ongoing collaboration between universities and schools are strongly recommended. Future community service activities should consider extending training duration, incorporating digital learning tools, and strengthening teacher capacity to independently implement data-based and environmentally oriented learning practices.

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