

Implementation of Sensor-Based Automatic Trash Can Technology to Improve Waste Sorting Awareness at Nusaputera National School in Semarang

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Abstract

Good waste management is one of the current global challenges. Schools are one of the places to form environmental awareness among students. Nusaputera National School in Semarang, as a partner in this community service program, faces problems related to the lack of education on good waste sorting and limited infrastructure that supports these activities. To overcome this problem, this community service program implements automatic sensor-based trash can technology that facilitates the waste disposal process so that students' awareness of waste management can increase. Through information dissemination and education involving students and teachers from various levels of education, this program has succeeded in increasing understanding of proper waste sorting. Evaluations conducted during the implementation of the program showed that the automatic trash can technology succeeded in attracting students' interest and increasing their awareness of the importance of waste management. The sustainability of this program is planned by providing further training for teachers and students and introducing the same technology to other schools in the Semarang area. The results of this program are expected to have a wider impact in creating a culture of sustainable waste sorting in the educational environment, while supporting Nusaputera National School's vision in realizing technology-based and environmentally friendly education.

Keywords: *automated trash can, environmental education, Nusaputra National School, waste management, waste sorting*

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Introduction

Raising environmental awareness has become a top priority in various sectors, including in the world of education. Schools play an important role in shaping students' behavior and views on the importance of maintaining environmental sustainability (Hariyono et al., 2013; Rahayu et al., 2024; Yusuf, 2024). One of the environmental challenges currently being faced is the problem of waste management, especially in terms of ineffective waste sorting (Lingga et al., 2024; Sari et al., 2023). Students who are not given education about waste sorting from an early age may not be aware of the harmful impacts of improper waste management (Marlina et al., 2023). With good waste management taught from an early age, it is expected that waste production and the negative impacts of waste can be minimized (Manurung et al., 2024).

Nusaputera National School (*Sekolah Nasional Nusaputera*), located in Semarang, as a partner in this community service program, is an educational institution that has a vision to produce quality graduates with an entrepreneurial spirit that has a global perspective and is based on noble character. In this collaboration, the school not only acts as an implementation site but also as an active partner that provides pedagogical input on the most effective approaches for students and facilitates direct student involvement in every stage of the program, from needs analysis to evaluation. This vision is realized through four main pillars, namely digitalization of education, English day, further study, and literacy. One important pillar, namely digitalization of education, is very relevant to this community service program, which focuses on developing technology to support learning about environmental awareness.

Nusaputera National School has several education levels, including elementary, middle, higher, and vocational school. This makes the Nusaputera National School a strategic location for implementing environmental education programs evenly. Currently, the waste sorting facilities at partner locations, such as existing trash cans, are still not optimally used, so there needs to be an improvement in facilities to increase environmental awareness among students. In addition to improving waste sorting facilities, education related to waste sorting should be integrated into the curriculum to foster a deeper understanding of environmental sustainability among students.

To overcome these problems, a community service program was carried out to implement automatic sensor-based trash can technology with three waste sorting holes. This technology

was designed to attract interest from students who were already familiar with current technology, while increasing the effectiveness of waste management in the school environment (Ahmad et al., 2020; Pamudji et al., 2025; Silolongan & Apriyono, 2019). In addition, this program includes information dissemination and training activities for students and teachers on the importance of waste sorting and how to use this technology optimally.

This community service is part of a grant program funded by the BIMA program from the Ministry of Education, Culture, Research, and Technology. Through this program, activities are designed to support the achievement of the goals of *Merdeka Belajar Kampus Merdeka (MBKM)* and the Key Performance Indicators (*IKU*) of higher education. (Baharuddin, 2021). The program engages students as ambassadors of change, giving them hands-on experience outside of campus while leveraging the work of faculty to provide real solutions for the community.

This community service activity aims to provide solutions to various problems faced by Nusaputera National School, especially in terms of waste management and the use of technology to support the digitalization of education. One of the main problems faced was how to improve students' education and awareness of the importance of waste sorting from an early age, which was a major challenge in forming environmentally friendly habits among students. The lack of understanding of students regarding the correct ways to sort waste leads to the habit of littering, which has the potential to damage the environment. Therefore, efforts were needed to design effective information dissemination and education programs so that students can better understand the concept of waste sorting and apply it in their daily lives.

On the other hand, one of the innovations implemented in this community service was sensor-based automatic trash can technology (Xiao et al., 2021; Wasistha et al., 2024). This technology is expected to be a solution to help students be more interested in sorting waste properly. Apart from that, it is expected that this technology can increase awareness regarding SDGS action (Aqilah et al., 2021), especially for SDGs number 4 (Quality Education), 11 (Sustainable Cities and Settlements), and number 12 (Responsible Consumption and Production) (Alcántara-Rubio et al., 2022). However, the challenges in implementing this technology include aspects of infrastructure that need to be adjusted to school needs, acceptance of technology by students and teachers, and the effectiveness of using this technology as a tool in waste sorting education.

Therefore, it was important to design a monitoring system that can measure the level of success of using this technology in improving students' waste sorting behavior.

With this collaboration, Nusaputera National School was not only a partner in implementing technology, but also a role model for other schools in Semarang in integrating technological innovation with environmental education effectively. Through an approach that combines technology, education, and community empowerment, this program is expected to provide a sustainable, positive impact on partners, students, and the surrounding community, while strengthening the synergy between universities and the community through the BIMA program.

Methods

The methods used in this community service:

1. Analysis of needs and existing conditions: a survey was conducted to analyze the existing conditions of waste management at Nusaputera National School. This analysis includes collecting data on existing waste sorting infrastructure, environmental awareness of students and teachers, and understanding of the importance of waste sorting. Specifically, the methods used were observation during break time in the canteen and field areas to identify general student behavior in disposing of trash, and also in-depth interviews with the teacher in charge of cleaning and the school principal to understand the challenges and existing facilities. This community service survey was conducted using interview and direct observation methods at the Nusaputera National School. The data obtained was used to design appropriate technology and information dissemination strategies so that students gain knowledge related to the environment. In addition, the data obtained was also used to create technology that can be used to meet the specific needs of schools, as well as ensuring that the technology applied is in line with the current capabilities and gaps identified in waste management practices. In addition, by involving students and teachers in this process, this program would provide a sense of ownership and collaboration, which is very important for the successful implementation of the proposed waste sorting solution.
2. The design and development of technology is based on the analysis of current conditions: the next step is the creation of automatic trash can technology with sorting holes using sensors. This device was developed using an Arduino Nano microcontroller as the main

processing unit. An FC-51 infrared sensor is used for object detection (hands or trash). The opening and closing of the trash lid are activated by a Tower Pro MG90S servo motor. These components were selected based on affordability, market availability, and ease of programming, allowing for future replication by schools. The development was carried out by the community service team, involving students as assistants in the manufacturing process. This process includes design, selection of the right materials, and prototype testing to ensure functionality and technical durability. During the design and development stage, students developed the trash can by integrating it with existing sensors, such as servos, so that it can open and close automatically. After the trash can is finished, the testing process was carried out to get feedback from the developer to ensure that the trash can runs well when the information dissemination activity is carried out at school.

3. Information dissemination and education: this stage involves information dissemination to students and teachers regarding the importance of waste sorting and the use of automatic trash can technology. Dissemination was carried out through seminars, workshops, and activities. The purpose of this dissemination is to increase students' understanding of the correct ways to sort waste and teach them how to use the newly implemented technology.
4. Evaluation of program impact: after the implementation stage was completed, an analysis of the results of the community service was carried out, both in terms of the impact on student behavior in sorting waste and in terms of the effectiveness of the technology applied. Data collected during the implementation and evaluation process is obtained qualitatively in the form of interviews to see how much influence the program has on students' environmental awareness and the sustainability of waste management in schools.

The community service method process is shown in Figure 1 which explains the community service flow.

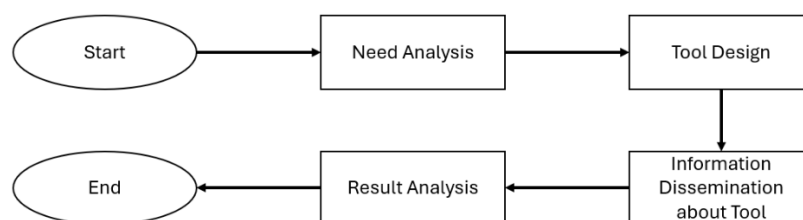


Fig. 1. Community service flow

Results and Discussions

Analysis of Existing Conditions

In the first stage, the community service team conducted an analysis of the existing condition of waste management at Nusaputera National School. The analysis process was carried out through field observations and interviews with one of the teachers at the school. The results of the analysis showed that although this school has basic facilities for waste management, such as trash cans spread across several points, waste sorting has not been carried out systematically and effectively. As seen from Figure 2, the trash can infrastructure at the location is still unable to facilitate waste sorting activities properly.



Fig. 2. Existing condition explanation from partner

Development of Automatic Trash Can Technology

Based on the analysis of the school's existing conditions during interviews and observations, the community service team developed sensor-based automatic trash can technology to support more effective waste sorting. This technology uses an Arduino equipped with infrared sensors and servos to detect the presence of waste and open and close the trash can automatically. In addition, this automatic trash can is equipped with three sorting holes (organic, inorganic, and hazardous). The development process was carried out by the community service team, assisted by student assistants, to create a prototype of the trash can, which will later be submitted to Nusaputera National School. The determination of three sorting holes, namely organic, inorganic, and hazardous (hazardous waste), in this automatic trash can is very important for effective waste management and environmental sustainability, and needs to be properly designed so that the school's vocational education in computer engineering and networking could apply the technology for realization.

The organic waste hole is designed to collect biodegradable materials, such as food waste and garden waste, which can be composted to produce nutrient-rich soil, thereby reducing landfill waste. Inorganic waste hole targets recyclable materials such as plastic, metal, and glass, to encourage recycling efforts that conserve natural resources and minimize pollution associated with landfills. And finally, a hazardous waste hole is essential for handling hazardous materials, such as batteries and chemicals, which can pose significant risks to human health and the environment if not managed properly. By providing these special sorting pits, automatic waste cans not only improve community waste management practices but also reinforce the importance of recycling and environmental stewardship among students.

Figure 3 provides a behind-the-scenes look at the development process of this technology, which actively involved students from the community service team. The image documents the crucial stages, from the meticulous assembly of physical components to the writing and testing of program code to organize the system's logic.



Fig. 3. Development of automatic trash can technology

Information Dissemination and Education to Students and Teachers

The next stage carried out was information dissemination regarding the importance of waste sorting and training in the use of automatic waste can technology, which was carried out through a series of seminars and workshops held at partner locations. In the dissemination activities, students were introduced to three types of waste (organic, inorganic, and hazardous),

as well as the correct way to sort waste. In addition to explaining about waste sorting education, the workshops that were held also taught students and teachers who participated how to redevelop the automatic trash can tool, so that they could independently maintain the tool. The workshop was conducted for vocational students majoring in computer engineering and networking, because they already have basic knowledge related to microcontrollers and sensors, so they can better understand how the automatic trash can system works. A workshop was also held regarding the development of automatic sensors for students who participated in the activities. The sensor development workshop was conducted so that students at partner locations could implement and duplicate the tools, so that the number of trash cans could increase. Teachers were also involved in training on the use of automatic trash can technology so that they could accompany students in implementing daily waste sorting.



Fig. 4. Technology information dissemination and workshop

Figure 4 visually documents a training session provided by the community service team and students to the students at the vocational school *SMK Nusaputera*. This image captures a moment of direct interaction, where the team explains how the system works and provides a basic understanding of the technology behind it.

Impact Analysis on Environmental Awareness

Analysis of the impact of this program on students' environmental awareness showed positive results. Students claimed to be more aware of the importance of waste sorting and felt more responsible for maintaining the cleanliness of the school environment. This shows that the

implementation of automatic trash can technology combined with good information dissemination can increase students' awareness in terms of waste management in the school environment.



Fig. 5. Results of the questionnaire to students

The analysis process was carried out by sending a Google Form to workshop participants. From the results of the questionnaire, as many as 22 respondents who filled out the questionnaire

form stated that the majority already understood how to sort waste properly according to the instructions explained. Then, most of the respondents also understood how the technology in the trash can works related to the sensors embedded in the trash can. And regarding questions related to their interest in developing the technology, most respondents were also interested in learning more about the technology.

This enthusiasm not only reflects their new awareness but also shows a desire to take the initiative in promoting sustainable practices in their school environment by utilizing existing technology. In addition, these positive findings can be the foundation for developing future educational programs that build on this momentum, ensuring that the importance of environmental management remains a major focus in sustainable education.



Fig. 6. Implementation of automated trash can

Quantitative evidence of the program's success is visualized in Figure 5, which presents a graphical representation of the questionnaire results. The graph compares students' levels of understanding and interest before (pre-test) and after (post-test) the training.

The implementation of the use of automatic trash cans is carried out for students from kindergarten to vocational school levels, with the aim that students of all levels have the knowledge and skills to participate in good waste sorting. This comprehensive approach not only fosters environmental awareness among students but also encourages a culture of sustainability that can be applied at home and in the community, and encourages responsible waste management practices at all levels of the school.

Conclusion

The conclusion obtained from the community service activities at Nusaputera National School shows that the information dissemination and implementation of sensor-based automatic trash can technology can be used effectively to increase students' awareness of waste sorting in the school environment. Through a combination of technology, information dissemination, and training, this program has succeeded in creating positive changes in students' behavior towards waste management. Students become more understanding and concerned about the waste sorting process, which includes organic, inorganic, and hazardous waste. The sustainability of this program is also key to expanding its impact in the future. Continuous training still needs to be carried out so that students increasingly understand the latest technological developments and the implementation of waste management. To ensure continued success and a deeper understanding, it is important to carry out follow-up sessions and maintenance activities that allow students to engage with technology more comprehensively. In addition, involving parents and the wider community in educational initiatives can also increase awareness and compliance with proper waste management practices, thereby creating a more sustainable environment in the wider community.

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