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Optimizing security in Desa Wiyata Tech through Smart Door Lock Implementation: Kutamanah Village, Purwakarta

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ABSTRACT

Security remains a fundamental concern in many rural educational facilities, where limited infrastructure often leads to increased vulnerability. The "Smart Door Lock" community service program aims to enhance security in public facilities, focusing on SDN 1 Kutamanah in Kutamanah Village, Purwakarta. This initiative is in response to frequent security challenges at the school, highlighting the need for a robust and efficient security solution. The project employs Internet of Things (IoT) technology, installing a Smart Door Lock with anti-theft sensors and a low-power infrared sensor system adapted for limited network areas and energy constraints. The participatory approach involved design, implementation, and user training phases to ensure sustainable operation by the local community and school personnel. Results show improved facility security, especially in high-risk and frequently accessed areas, fulfilling the Sustainable Development Goals (SDGs) of community safety and infrastructure resilience. This technology serves as a model for enhancing security in other public spaces within the village, promoting safety, technological adaptation, digital literacy, and local innovation in rural areas. The project also fosters collaboration between academia, local government, and the community for long-term impact and replicability.

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1. INTRODUCTION

Security is one of the key factors in sustainable development efforts in rural areas (Kementerian Desa Pembangunan Daerah Tertinggal dan Transmigrasi, 2023). The Village Sustainable Development Goals (SDGs), derived from the National SDGs, focus on development encompassing economic, social, environmental, legal, and governance aspects, including improving security in public facilities to support community welfare (Hafni et al., 2021; Iskandar, 2020). Referring to Presidential Regulation No. 59 of 2017 and Ministerial Regulation of Villages PDTT No. 13 of 2020, concrete efforts are needed to achieve sustainable development goals at the village level to reduce the gap between urban and rural areas (Hafni et al., 2021). Research by Sneddon et al. (2006) highlights the importance of social and environmental sustainability in addressing security challenges, especially in disadvantaged areas (Pizzi et al., 2020).

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The Village Sustainable Development Goals (SDGs), derived from the National SDGs, emphasize development that covers economic, social, environmental, legal, and governance aspects, including security improvements in public facilities to support shared welfare (Hafni et al., 2021; Iskandar, 2020). Villages in Indonesia play a crucial role in achieving the National SDGs. Around 43 percent of Indonesia's total population lives in rural areas, and these villages contribute significantly to 74 percent of the total national SDGs achievements. This underscores the essential role of villages in achieving SDGs (Nugroho et al., 2022).

These challenges require new strategies that integrate human- and environment-based development principles to improve the quality of life in rural communities (Sugandi et al., 2022). To address these challenges, the Indonesian government has established various regulations directing village development toward SDG achievement. For instance, under Presidential Regulation No. 59 of 2017 and Ministerial Regulation of Villages PDTT No. 13 of 2020, concrete efforts are required to achieve sustainable development goals at the village level, aiming to reduce the gap between urban and rural areas and enhance security in public facilities such as elementary school offices in Sukasari Village (Hafni et al., 2021; Nugroho et al., 2022; Sugandi et al., 2022). The Village Fund Program also aims to improve access to basic infrastructure and enhance the quality of life for rural communities through various development initiatives.

In Purwakarta Regency, inadequate infrastructure and low security levels are reflected in the Safe and Comfortable Village Settlement Index (SDGs 11), which only reaches 46.19, posing a challenge in improving the quality of life in rural communities (Kementerian Desa Pembangunan Daerah Tertinggal dan Transmigrasi, 2023). One example is in Kutamanah Village, Sukasari District, Purwakarta Regency, particularly in Kiarabandung Hamlet, which is the target of the Desa Wiyata Tech program from the Mechatronics and Artificial Intelligence Study Program at the Indonesian University of Education, Purwakarta Campus. Based on discussions with village officials, areas requiring security infrastructure improvements are public spaces. A field survey identified one crucial location needing enhanced security: the elementary school office, which houses various important school assets and requires a reliable security system. The field survey pointed to SDN 1 Kutamanah, Kiarabandung Hamlet, Kutamanah Village, Sukasari District, Purwakarta Regency, which is vulnerable and frequently experiences theft-related crimes.

Amid the ongoing technological revolution, there has been a significant increase in network automation and IoT technology integration, expanding connectivity and functionality across various sectors, including healthcare, business analytics, and education (Kementerian Desa Pembangunan Daerah Tertinggal dan Transmigrasi, 2023; Najib et al., 2020). IoT has rapidly evolved, with an estimated 50 billion IoT devices connected to the internet by 2020, reflecting the massive global adoption of IoT (AlSalem et al., 2023). The proliferation of IoT has also extended beyond local workstations to industrial systems, demonstrating broader implementation and increasing reliance on IoT systems in critical fields (Najib et al., 2020; Rachit et al., 2021). The use of IoT in daily life has brought significant transformations, particularly in home environments, where smart home applications automate various tasks and enhance user convenience (Rachit et al., 2021).

As a solution, this community service program aims to design and implement an Internet of Things (IoT)-based device in the form of a Smart Door Lock with enhanced anti-theft features, which will be installed in a public facility, namely SDN 1 Kutamanah. This security system is designed to operate efficiently in areas with limited network connectivity. Enhancements have been made by adding an infrared-based anti-theft sensor that operates independently from the main Smart Door Lock system. This separate sensor helps conserve power by not relying on a continuous Wi-Fi connection, which has

limited signal strength in Kiarabandung Hamlet and poses a risk of faster battery depletion (Adiono et al., 2019; Hidayat et al., 2018; Laurens, 2006; Maier et al., 2017).

Unstable connections force devices to repeatedly reconnect, leading to unnecessary power consumption as this process continuously draws more energy. Similar to the FiWi and C-RAN concepts, energy consumption increases when connectivity is unstable, as devices cannot enter power-saving modes such as sleep mode (Lorincz et al., 2023). By separating the anti-theft sensor from the Wi-Fi-dependent system, this solution can reduce overall power demand and ensure the device remains efficient without relying on often unstable connectivity.

This solution supports the Village SDGs by enhancing security in public facilities while leveraging technology to address infrastructure challenges in rural areas. The program also aligns with the Indonesian government's goal of optimizing the use of the Village Fund to improve quality of life and ensure sustainable development at the village level, contributing to the achievement of SDGs at both national and global levels (Lestari et al., 2023; Nugroho et al., 2022). By utilizing IoT technology, Sukasari Village can serve as a model for implementing innovations to enhance security and the quality of life in rural communities.

2. METHODS

Desa Wiyata Tech is an innovative initiative by the Mechatronics and Artificial Intelligence Study Program at the Universitas Pendidikan Indonesia, Purwakarta Campus, aimed at developing a technology- and education-based village. Through this program, technology is directly applied within the community to enhance education quality, strengthen security, and promote sustainable development, thereby creating a smarter and more competitive village environment. The year 2024 marks the first implementation of this community service program as a realization of the roadmap for community service activities (PkM) in the field of technological innovation, as illustrated in Figure 1.

The implementation of this community service initiative begins with planning the time and location of activities, followed by evaluating the program's execution. The preparation and evaluation process spans three months, from June 2024 to August 2024. This chapter discusses the activity design, program implementation methods, schedule, and stages of execution, as well as the evaluation framework for assessing the effectiveness of the community service activities conducted.

Activity Plan

The community service program began with a pre-survey of three village locations in Purwakarta Regency: Pasirjambu Village, Jatiluhur Village, and Kutamanah Village. Kutamanah Village, located in Sukasari District, Purwakarta Regency, was selected as the target for the Assisted Village initiative due to its high potential for implementing the planned roadmap for PkM (as shown in Figure 1) over the next five years, one of which includes enhancing security through the implementation of a smart door lock system. This village presents significant opportunities for the application of various technologies that can transform it into Desa Wiyata Tech Purwakarta.

The program continued with surveys and interviews involving village officials and community representatives at the Kutamanah Village Office. Based on these discussions, the primary target audience for the smart door lock system implementation was identified as the school community at SDN 1 Kutamanah. The installation of the smart door lock aims to enhance security for the rooms within the school. The required equipment is listed in Table 1.

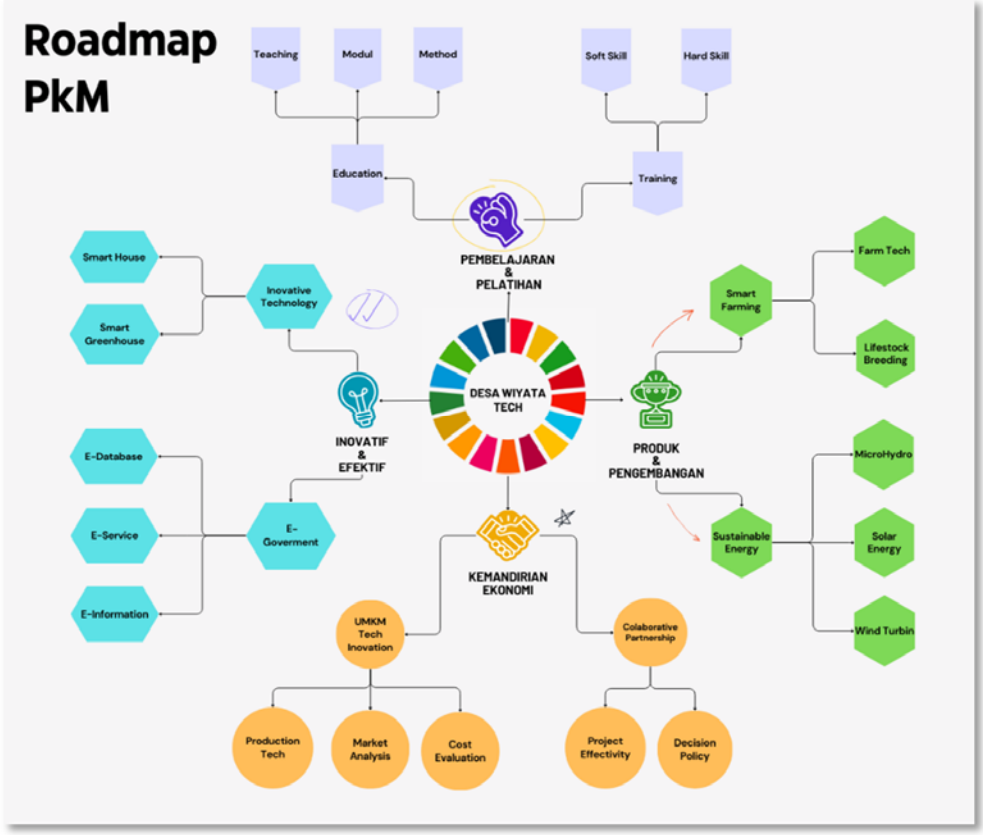

Figure 1. Roadmap of PkM Department of Mechatronics and Artificial Intelligence, Indonesian University of Education, Campus in Purwakarta

Table 1. Tools and materials needed during the activity

Tools	Description
Wood drill	To help make a new key housing that matches the shape of the smart door lock that will be installed
Chisel	To help make a new key housing that matches the shape of the smart door lock that will be installed
Flashlight	Additional lighting when installation is carried out at night
Materials	**Description**
2 smart door locks	Installed on the door of the teacher's room and 1 classroom
ESP 32	Functions to process data and send data to the database
Infrared sensor	Functions to detect door movement and mortise locking
LEDs	Status indicator in the system
Power supplies	Provides power for the entire series of tools
Chassis	Component holder and circuit protector
Nut and bolt	
Glue	
Chargeable battery	The system is equipped with a rechargeable battery, making it more cost-effective for users later.

Implementation Method

In this community service program, the methods used include participatory methods, design and implementation, as well as survey and qualitative approaches. These methods are employed to design, implement, and evaluate a technology-based security solution at SDN 1 Kutamanah, Kutamanah Village, Sukasari District, Purwakarta Regency. The steps taken are as follows: (1) Site Survey and Data Collection (Survey and Qualitative Method). Direct interviews with the community and school representatives were conducted to identify security issues and technological needs. The qualitative data collected ensures that the solutions implemented are relevant and effective, aligning with the principles of implementation science, which emphasize the importance of participation in designing solutions (Hwang et al., 2020; Yadav, 2022); (2) Technology Design and Implementation (Design and Implementation Method). Based on the survey results, a Smart Door Lock with an infrared-based anti-theft sensor was installed at designated locations. This technology is designed to overcome Wi-Fi limitations and provide security adapted to local conditions. This collaborative design approach ensures that the implemented solution is relevant to the community context (Vaughn & Jacquez, 2020); (3) Usage and Maintenance Socialization (Participatory Method). After installation, socialization and training sessions were conducted for the community regarding the use and maintenance of the device. This approach encourages ownership and responsibility, which are essential for the sustainable use of technology (Vaughn & Jacquez, 2020); (4) Evaluation through Satisfaction Surveys (Survey and Qualitative Method). A satisfaction survey was conducted to evaluate the effectiveness of the installed device and assess community satisfaction. This evaluation covers the effectiveness and outcomes of the implementation, following a methodology that prioritizes continuous evaluation (Hwang et al., 2020).

Site survey and Data Collection

The PkM implementation team conducted surveys in three villages in Purwakarta: Pasir Jambu Village, Jatiluhur Village, and Kutamanah Village. Based on the location and condition of village facilities, Kutamanah Village emerged as an excellent candidate for the Assisted Village program. The possibility of executing the PkM Roadmap over the next five years is highly feasible. The team also conducted an informal survey among village residents to assess the viability of implementing the PkM with the proposed topic and roadmap. Based on these findings, the PkM was carried out specifically in Kiarabandung Hamlet, Kutamanah Village, Sukasari District, Purwakarta Regency.

Figure 2. Site survey and data collection in Kiarabandung Village, Kutamanah Village

Observations were conducted on June 2 and June 9, 2024, through village officials. The village representatives then guided the team around areas where the system could be implemented, as illustrated

in Figure 2. Since the local residents were still unfamiliar with the system, the implementation team initially conducted a trial before installing the smart door lock in a public facility. The target audience for the smart door lock system is the school community at SDN 1 Kutamanah. The installation of the smart door lock aims to enhance security for the rooms within the school, aligning with the results of discussions held with local village officials.

The most strategic location that was finally determined was the installation of smart door locks in classroom 1 and the teacher's room of SDN 1 Kutamanah as shown in Figure 3. The selection of a location in the school area can be a means of promoting the technology applied to a wider audience.

Figure 3. Smart door lock system installation location

Technology Design and Implementation

This stage aims to design the system and procure all necessary tools and equipment for the PkM implementation. The team must ensure that all components function according to their specifications, preventing discrepancies between the design and the final system outcome. The system design phase was carried out during the third and fourth weeks of June 2024, while the system implementation was scheduled for three days, from July 18 to July 20, 2024.

The anti-theft detection system consists of two main components: a physical sensor device and a digital application. Each component plays a complementary role in ensuring optimal security. The physical sensor device detects movement and door locking activities. The data collected from this device is then transmitted and stored in an online database. The physical system is developed using a microcontroller along with multiple detection sensors, as illustrated in the schematic in Figure 4.

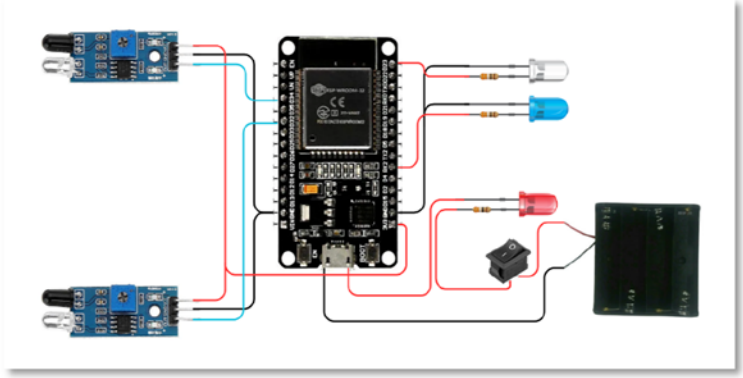

Figure 4. Schematic of the anti-theft component in the smart door lock system

Socialization of Utilization and Maintenance

After the system installation, a socialization and training session was conducted to educate the community on the use and maintenance of the device. This approach fosters ownership and responsibility, which are crucial for the sustainable use of the technology [17].

The smart door lock socialization session was planned for the teachers of SDN 1 Kutamanah. This session aimed to provide an overview of how to access the system and the necessary steps to take in case of any issues with the installed smart door lock.

Evaluation through Satisfaction Questionnaire

One month after the system installation, namely in August 2024, a check and evaluation will be carried out through a user satisfaction questionnaire on the smart door lock system. The questions in the questionnaire have an answer scale of 1 to 5 where the best value is 5. The list of questions in the questionnaire can be seen in Table 2.

Table 2. Smart door lock system user satisfaction survey at SDN 1 Kutamanah

Tools	Response Scale
How easy is it for you to use the smart door lock to access the teacher's room?	Scale 1 (very difficult) – 5 (very easy)
Are the instructions for using the smart door lock provided clear enough?	Scale 1 (very unclear) – 5 (very clear)
Do you feel comfortable with how the smart door lock works?	Scale 1 (very uncomfortable) – 5 (very comfortable)
How effective is the smart door lock in improving the security of the teacher's room?	Scale 1 (very ineffective) – 5 (very effective)
Do you feel safer with the smart door lock?	Scale 1 (very unsafe) – 5 (very safe)
In your opinion, what are the main shortcomings of the smart door lock?	Open question
Your suggestions or input for improving the smart door lock	Open question
Overall, how satisfied are you with using the smart door lock?	Scale 1 (very dissatisfied) – 5 (very satisfied)

Evaluation Design

In the implementation of the community service program for the Smart Door Lock system at SDN 1 Kutamanah, Desa Sukasari, three main criteria serve as benchmarks for its success. The program's success is measured by the adherence to the planned schedule, which requires strong collaboration between the implementation team and the partners. From the partners' perspective, success is evaluated based on the effectiveness of the smart door lock in enhancing security in public areas, such as the teachers' office and classrooms. Partners are also expected to independently operate the smart door lock system and understand the methods used to improve school security. Additionally, they should be capable of maintaining the system in case of any future issues.

From the implementation team's perspective, success is measured by their ability to provide clear explanations and support to partners encountering difficulties in using the system. Furthermore, the successful installation of the smart door lock system, ensuring ease of use and acceptance by partners, is also a key indicator of success. All evaluations will be conducted through a user satisfaction survey system.

3. RESULTS AND DISCUSSION

Smart Door Lock Implementation

The main installation of the Smart Door Lock system took place from July 18 to 20, 2024, as part of efforts to enhance school security. During this process, the community service team dismantled the classroom and teachers' office doors, a necessary step to ensure the new system could be installed perfectly.

Since the existing doors were fragile and prone to damage, extra care was required when chiseling the wood and creating a new key housing pattern. This meticulous process ensured that the smart door lock was installed with precision without compromising the structural integrity of the doors. The team also carefully measured the dimensions and positioning of the key housing to ensure seamless integration of the security device with the existing door design.

This effort was carried out with great attention to detail, balancing the preservation of existing doors while incorporating new technology to create a safer school environment. Figure 5 provides documentation of the installation process, showing the replacement of the conventional door system with the Smart Door Lock components.

Figure 5. Smart door lock main system installation process

Implementation of Anti-Theft Components on Smart Door Locks

The anti-theft system, which was developed according to the designed specifications, was assembled into a single chassis to ensure a neat arrangement and protection from external factors. Once packaged, the physical device was installed on the door to detect intrusions, as shown in Figure 6.

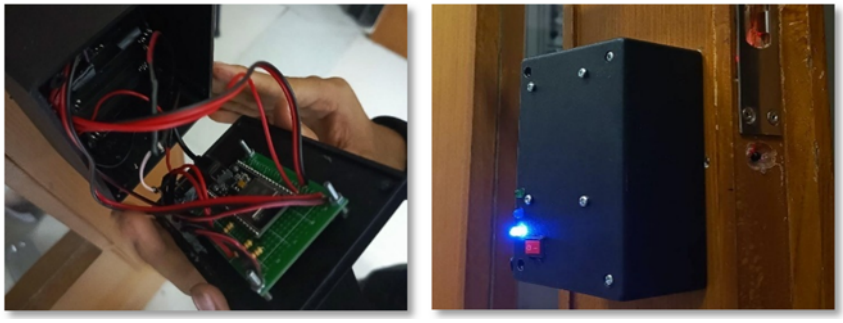

Figure 6. Anti-theft system hardware components

The digital component of the anti-theft system in the form of an application developed using Android Studio and Firebase as a data storage center is shown in Figure 7. This application functions to receive and process data stored in the online data center, determining whether there is an intruder or not. If the application detects an intruder, the user will receive an alert berupa notifikasi visual dan audio. With this design, the intruder detection system is able to operate effectively, combining integrated sensor hardware and digital applications.

Figure 7. Anti-theft system software components

The theft detection system has the following workflow such as: (1) System Initialization. The system can be activated using the switch located on the chassis. When the red LED light turns on, it indicates that the system is powered on. The blue LED will light up once the WiFi connection is successfully established, while the white LED signals that the system has successfully connected to the central database; (2) Motion Detection and Door Lock Monitoring via Infrared Sensors. The system utilizes two infrared sensors. The first sensor detects the movement of the door panel, determining whether the door is open or closed. The second sensor monitors the status of the mortise lock, ensuring whether the door is securely locked. The detected data from both sensors is transmitted to the central database for continuous updates; (3) Lock Mechanism Activation. The locking mechanism activates when the infrared sensors confirm that the door is closed and the mortise lock is engaged. If the mortise lock is engaged while the door is open, the system detects an intrusion and triggers a warning. Conversely, if the mortise lock is not engaged, regardless of the door being open or closed, the system does not register an intrusion threat; (4) Warning Alarm. If the system detects an intrusion, the connected application will issue an audio-visual alarm to alert users. This alarm can be deactivated at any time via the application; (5) Security System Monitoring. In addition to providing alerts, the connected application allows users to monitor the physical security system remotely. This enables users to check the door's security status anytime and anywhere.

With this method of working, the theft detection system can provide optimal and flexible security protection that can be accessed via digital applications anywhere.

Socialization

Socialization of the use of smart door locks was held with participants, namely teachers from SDN1 Kutamanah as shown in Figure 8. Socialization was carried out to provide an explanation regarding how to access the system and what to do if there is a problem with the installed smart door lock.

Figure 8. Socialization of the smart door lock system to users

Evaluation

One month after the installation of the smart door lock, four school members who directly used the system were asked to complete a user satisfaction survey. This survey aimed to assess the effectiveness and benefits of the system. Overall, the school community responded very positively to the installation of the smart door lock.

Feedback from users included a request for the system to be installed in more locations, particularly in additional classrooms. Additionally, they expressed a desire for the system to be implemented in other public areas within the village that require enhanced security. A snapshot of the survey results can be seen in Tabel 3.

Table 3. User satisfaction survey results

Items	Satisfaction Results				
	Not Satisfied	**Less Satisfied**	**Fairly Satisfied**	**Satisfied**	**Very Satisfied**
How easy is it for you to operate the smart door lock for entering and exiting the teachers' room?	0	0	0	2 (50%)	2 (50%)
Are the instructions for using the smart door lock sufficiently clear?	0	0	0	1 (25%)	3 (75%)
How effective is the smart door lock in enhancing the security of the teachers' room?	0	0	0	2 (50%)	2 (50%)
Overall, how satisfied are you with the use of the smart door lock?	0	0	0	2 (50%)	2 (50%)
Do you feel more secure when using the smart door lock?	0	0	0	2 (50%)	2 (50%)

Obstacles and Solutions

During the implementation of this community service program, several challenges needed to be addressed: (1) Hardware Issues – Screws often got stuck, requiring cutting or securing with the appropriate tools; (2) Limited Equipment – The availability of necessary tools was sometimes insufficient, requiring borrowing from experts or finding alternative solutions; (3) Material and Infrastructure Limitations – Resources in rural areas were often scarce, necessitating extra effort to source materials, sometimes from distant locations; (4) Internet and Environmental Constraints – Poor network infrastructure in some villages hindered program execution. Additionally, inadequate lighting during installation required the preparation of additional light sources; (5) Component Availability – Some specific equipment and components were difficult to find locally, necessitating online purchases; (6) Social Challenges – Encouraging the community to adopt new technology, such as smart door locks, required careful and clear communication to ensure acceptance and understanding.

4. CONCLUSION AND RECOMMENDATIONS

This community service program aims to introduce smart door lock technology to the residents of Kampung Kiarabandung, Desa Kutamanah, Kecamatan Sukasari, Kabupaten Purwakarta, particularly at SDN 1 Kutamanah. The primary goal is to design and implement an Internet of Things (IoT)-based smart door lock with enhanced anti-theft features to improve security and order in the village. The implementation of the smart door lock at SDN 1 Kutamanah has proven effective in enhancing security and safety, especially for school residents in public areas. This technology provides a practical solution to reduce theft risks in rural areas, particularly in public facilities. Through a participatory and empowerment approach, this program not only strengthens physical security but also fosters community independence in utilizing security technology.

It is recommended to expand the use of smart door locks to various public areas, including frequently accessed community facilities, to enhance the coverage of technology-based security. To support the implementation of this IoT technology, improving internet access in rural areas should be prioritized, ensuring a more robust infrastructure for the seamless operation of security technology. Additionally, continuous socialization and education are necessary to help the community better understand the benefits of this security technology. This will encourage more people to adopt similar systems, contributing to the development of a safer Desa Wiyata Tech.

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