

Empowering Environmental and School Facilities Management at SMP Negeri 4 Siak Hulu through the Implementation and Mentoring of Internet of Things (IoT) Technology

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Abstract

Background: SMP Negeri 4 Siak Hulu faced difficulties in monitoring classroom environmental conditions and managing classroom facilities due to the absence of an integrated monitoring and control mechanism. This program addressed these challenges through the implementation and mentoring of an Internet of Things (IoT)-based Smart Classroom system.

Aims: This program aimed to improve teachers' and school personnel's knowledge and practical skills in environmental monitoring and lighting control using an IoT-based Smart Classroom system.

Methods: The program consisted of four stages: situation analysis, system preparation, training and mentoring, and evaluation. The system employed an ESP8266 microcontroller with DHT11, LDR, and PIR sensors, a relay module, a 16×2 LCD, and an Android application developed using Kodular for environmental monitoring and lighting control. Evaluation involved 19 participants using a 14-item pre-test and post-test, complemented by observations of participants' basic system operation after mentoring.

Results: The mean score increased from 81.95% to 95.86%, representing a descriptive increase of 13.91 percentage points. The minimum score increased from 50.00% to 85.71%, while the maximum remained 100.00%. Thirteen participants (68.42%) increased their scores, 6 (31.58%) maintained the same scores, and none decreased. All 19 participants were observed performing basic operating procedures independently after mentoring.

Conclusion: The program was associated with improved participant knowledge and demonstrated basic independent operation of the implemented IoT-based Smart Classroom system. Long-term knowledge retention, system utilization, energy savings, and maintenance performance were not evaluated.

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INTRODUCTION

The increasing adoption of digital technologies has created new opportunities for schools to monitor classroom environments and support the management of educational facilities. Internet of Things (IoT) technology enables physical objects and environmental sensors to collect, transmit, and exchange data through connected systems, thereby supporting continuous monitoring and more responsive facility management (Hoàng, et al., 2025; Firdaus, et al., 2025; Sethi & Sarangi, 2017). Classroom environmental factors such as temperature, humidity, lighting, and occupancy are associated with students' comfort, attention, and learning conditions (Aydin & Göktaş, 2023; Brink et al., 2021; Wargocki et al., 2020). The application of IoT in educational and building environments also provides opportunities for environmental monitoring and data-informed facility management (Al-Obaidi et al., 2022; García-Monge et al., 2023).

Within educational environments, IoT technology can be used to develop Smart Classroom systems capable of collecting and monitoring classroom conditions through connected sensors and digital interfaces. Previous studies have identified IoT as an important technology for smart education and classroom environments, including environmental monitoring, classroom management, and technology-supported learning (Badshah et al., 2023; Chweya & Ibrahim, 2021; Kassab et al., 2020; Kaur et al., 2022; Wang et al., 2022; Zeeshan et al., 2022). IoT has also been increasingly applied to smart educational environments and campus management to support learning activities and optimize educational resources (Cavus et al., 2022). Recent studies have further demonstrated the use of IoT-based systems for classroom environmental monitoring, electrical control, and smart classroom applications (Dai et al., 2023; Ibrahim et al., 2024; Novaliendry et al., 2025).

Although various IoT-based Smart Classroom systems have been developed, previous studies have predominantly focused on system architecture, environmental sensing, occupancy detection, intelligent classroom technologies, or smart-building applications (Caballero-Peña et al., 2024; Chaudhari et al., 2024; Rueda et al., 2020; Saini & Goel, 2020; Shokrollahi et al., 2024). Other studies have investigated intelligent building automation, occupancy monitoring, and real-time data processing as technological approaches to improve building management (Elkhouchi et al., 2022; Masroor et al., 2023; Saha et al., 2019). However, translating these technologies into practical school environments requires not only system implementation but also user training, hands-on practice, mentoring, and technology transfer. Studies on IoT in education have emphasized the potential of these technologies, but practical adoption and sustained use by teachers and school personnel remain important challenges (Chweya & Ibrahim, 2021; Kassab et al., 2020; Paliktzoglou & Vlachopoulou, 2024).

The novelty of this community service program lies primarily in the practical adoption and technology transfer of an IoT-based Smart Classroom system to teachers and school personnel, rather than in the development of a new IoT hardware architecture. The program integrates real-time classroom environmental monitoring and lighting control with structured training, hands-on practice, and mentoring designed to enable participants to operate the implemented system independently. In addition to measuring changes in participants' knowledge through pre-test and post-test evaluation, the program also observed participants' basic operational abilities after mentoring. Thus, the main contribution of this program is the integration of IoT system implementation with a practice-oriented capacity-building approach that supports the transition from technological demonstration to practical use within a school environment.

SMP Negeri 4 Siak Hulu is one of the schools seeking to improve environmental monitoring and classroom facility management through digital technology. However, the school still faces limitations in continuously monitoring classroom conditions and controlling classroom lighting. Therefore, this community service program aims to empower teachers and school personnel through the implementation and mentoring of an IoT-based Smart Classroom system that monitors temperature, humidity, lighting intensity, room occupancy, internet connectivity, and classroom lighting status in real time through a mobile application. The program is intended to strengthen participants' digital

literacy and basic operational skills in using IoT technology for classroom environmental monitoring and lighting control, while providing a practical model that can be considered for adoption in other school settings.

METHOD

The community service program was implemented through a participatory training and mentoring model. A one-group-pretest-posttest design was employed to assess changes in participants' knowledge before and after the program (Hassan et al., 2025; Nam et al., 2023). The activities involved the introduction, implementation, hands-on practice, and use of an IoT-based Smart Classroom system at the partner school. The program was designed to strengthen the school community's ability to utilize IoT technology for monitoring classroom environmental conditions and supporting the management of school facilities.

The activity was conducted at SMP Negeri 4 Siak Hulu, Kampar Regency, Riau, Indonesia. The selection of the partner institution was based on the need to improve the utilization of digital technology in monitoring classroom environmental conditions and managing school facilities. The location of the community service activity is presented in Figure 1.

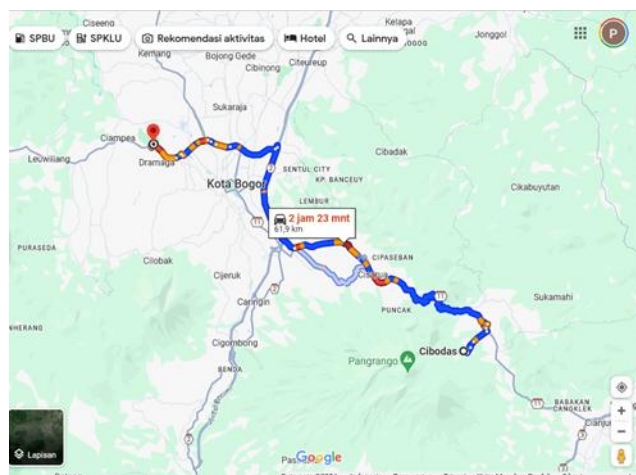


Figure 1. Location of the community service activity at SMP Negeri 4 Siak Hulu

The program was implemented through four main stages: (1) situation analysis, (2) preparation and system development, (3) training, implementation, and mentoring, and (4) evaluation. These stages were conducted sequentially to ensure that the IoT-based Smart Classroom system was not only implemented but also usable by the partner school. An overview of the four main stages of the community service program is presented in Figure 2.

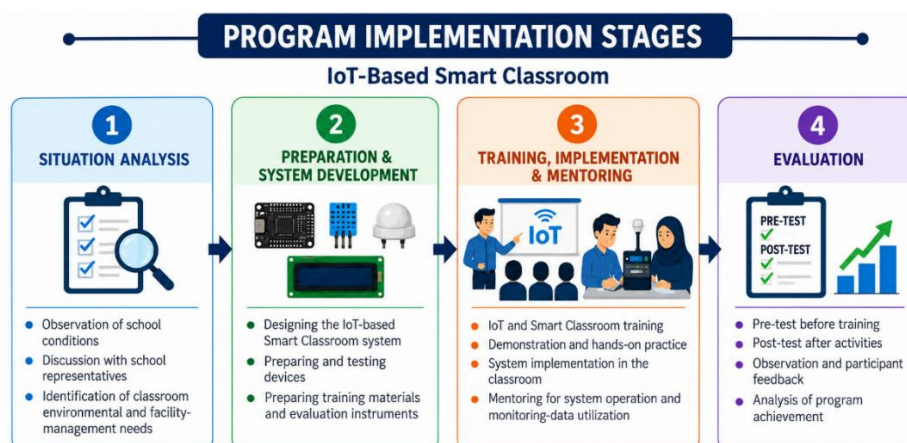


Figure 2. Stages of the community service program

The participants were teachers and school personnel of SMP Negeri 4 Siak Hulu who were involved in the utilization and management of classroom facilities and the school environment. A total of 19 participants took part in all program activities, including the pre-test, training, hands-on practice, mentoring, and post-test.

Participants were selected using purposive sampling based on their direct involvement in classroom facility management and their potential role in utilizing the IoT-based Smart Classroom system. The selection was coordinated with the partner school to involve personnel who were directly related to the use, supervision, and management of classroom facilities and the school environment. This selection procedure was intended to ensure that the participants could apply the knowledge and practical skills obtained during the program in the school environment.

The community service program consisted of four main stages. The first stage was situation analysis, which involved identifying the conditions and problems faced by the partner school through observation and discussion with school representatives (Farah et al., 2024; Iswatiningsih et al., 2021; Pusawidjayanti et al., 2024). The analysis focused on classroom environmental monitoring and the management of school facilities. The results of this analysis were used as the basis for designing the IoT-based Smart Classroom system.

The second stage was preparation and system development, which included the development and testing of the IoT-based Smart Classroom system, preparation of training materials, and preparation of evaluation instruments. The developed system utilized an ESP8266 microcontroller, DHT11 temperature and humidity sensor, LDR light sensor, PIR motion sensor, relay module, and I2C LCD display. The system was tested before implementation to ensure that the sensors, microcontroller, display, and lighting control functions operated properly. The main components and configuration of the IoT-based Smart Classroom system are illustrated in Figure 3.

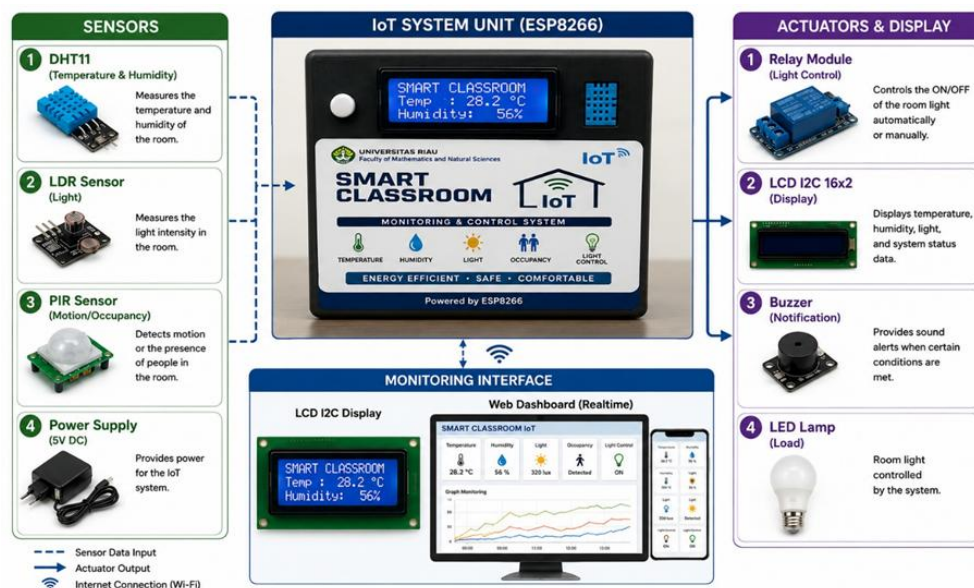


Figure 3. IoT-based Smart Classroom system and supporting devices

The third stage consisted of training, demonstrations, hands-on practice, system implementation, and mentoring. Participants were introduced to the basic concepts of IoT, the functions of the system components, environmental monitoring, and the use of the Smart Classroom system. The delivery of the IoT and Smart Classroom training materials is shown in Figure 4.



Figure 4. Delivery of IoT and Smart Classroom training materials

Following the demonstration, participants practiced reading sensor data, observing changes in classroom environmental conditions, interpreting information displayed on the LCD, and operating the classroom lighting control system. The participants' hands-on practice in operating the Smart Classroom IoT system is presented in Figure 5.



Figure 5. Participants practicing the operation of the Smart Classroom IoT system

For the purpose of the evaluation, independent operation was defined as the participant's ability to perform the basic operating procedures of the IoT-based Smart Classroom system without direct assistance or step-by-step instruction from the community service team. The observation focused on the participant's ability to check the system, read temperature and humidity information, interpret light and motion sensor information, read the information displayed on the LCD, and operate the classroom lighting control function. Participants were considered to demonstrate independent operation when they were able to perform the required basic procedures without direct assistance during the observation.

The system was subsequently implemented in the partner school's classroom environment to monitor temperature, humidity, lighting conditions, and classroom occupancy. The implementation of the IoT-based Smart Classroom system at the partner school is shown in Figure 6.



Figure 6. Implementation of the IoT-based Smart Classroom system at SMP Negeri 4 Siak Hulu

Mentoring was conducted during and after implementation to support participants in operating the system independently. The mentoring also focused on the use of monitoring data as supporting information for classroom environmental and school facility management.

The evaluation was conducted using pre-test, post-test, direct observation, and participant feedback. The pre-test was administered before the training to assess participants' initial knowledge, while the post-test was administered after the training and mentoring activities to measure changes in participants' knowledge. The implementation of the pre-test and post-test is illustrated in Figure 7 and Figure 8. Both tests consisted of 14 multiple-choice questions covering IoT concepts, Smart Classroom concepts, sensor functions, environmental monitoring, lighting control, interpretation of sensor data, and the utilization of IoT technology for classroom and school facility management.

Timestamp	Email Address	Score	Nama Peserta	Jabatan	Tanggal
12/08/2025 9:44:06	cctendriwati2@gmail.com	13 / 14	Citra Oliva S.Pd.	Guru	12/08/2026
12/08/2025 9:44:46	nurulmayani81@gmail.com	13 / 14	Nurul M	Guru	12/08/2026
12/08/2025 9:36:46	alrisaisa78@gmail.com	13 / 14	Alrisa	Guru	12/08/2026
12/08/2025 9:45:43	monikajya81@guru.smp.belajar.id	10 / 14	Monika Mye	Guru	12/08/2026
12/08/2025 9:45:45	restesa.rahmayunita2@guru.smp.belajar.id	13 / 14	Retesa Rahmayunita, M.Pd	Guru	12/08/2026
12/08/2025 9:45:53	lindasueni7@gmail.com	11 / 14	Linda Sueni	Guru	12/08/2026
12/08/2025 9:45:55	reisyafitri42@gmail.com	9 / 14	Revi Syafitri	Guru	12/08/2026
12/08/2025 9:46:27	silvia.yohana79@guru.smp.belajar.id	9 / 14	Silvia Yohana Sitanggang, S.Pd	Guru	12/08/2026
12/08/2025 9:46:33	novirnetid@gmail.com	12 / 14	Novirna Yanti Devita	Guru	12/08/2026
12/08/2025 9:46:45	latriniaiefendi82@guru.smp.belajar.id	14 / 14	Latrinaria efendi	Guru	12/08/2026
12/08/2025 9:46:55	ramiani17387@gmail.com	14 / 14	HSRA MARWATI, S. Pd	Guru	12/08/2026
12/08/2025 9:46:57	kiki.dwi194@guru.smp.belajar.id	7 / 14	KIKI EKA PUTRI, M.Pd	Guru	12/08/2026
12/08/2025 9:47:00	belolleda5@guru.smp.belajar.id	9 / 14	Belo Oleda	Guru	12/08/2026
12/08/2025 9:47:12	marlyantimiza@gmail.com	11 / 14	MARLIYANTI, S.P	Guru	12/08/2026

Figure 7. Implementation of the pre-test

Timestamp	Email Address	Score	Nama Peserta	Jabatan	Tanggal
13/08/2026 15:47:57	mariyani71@gmail.com	14 / 14	MARIYAM	Guru	13/08/2026
13/08/2026 15:54:48	alrissaa78@gmail.com	13 / 14	Alrissa	Guru	13/08/2026
13/08/2026 15:45:48	monikajaya81@guru.smp.belajar.id	14 / 14	Monika Mye	Guru	13/08/2026
13/08/2026 15:45:53	retesa.rahmayunita2@guru.smp.belajar.id	13 / 14	Retesa Rahmayunita, M.Pd	Guru	13/08/2026
13/08/2026 15:45:53	lindasueni7@gmail.com	13 / 14	Linda Sueni	Guru	13/08/2026
13/08/2026 15:45:55	reisyafitri42@gmail.com	12 / 14	Revi Syafitri	Guru	13/08/2026
13/08/2026 15:46:27	silvia.yohana79@guru.smp.belajar.id	13 / 14	Silvia Yohana Sitanggang, S.Pd	Guru	13/08/2026
13/08/2026 15:46:33	novirnetut@gmail.com	14 / 14	Novirna Yanti Devita	Guru	13/08/2026
13/08/2026 15:46:45	latriniafefendi82@guru.smp.belajar.id	14 / 14	Latrinaria efendi	Guru	13/08/2026
13/08/2026 15:47:03	kiki.dwi194@guru.smp.belajar.id	13 / 14	KIKI EKA PUTRI, M.Pd	Guru	13/08/2026
13/08/2026 15:48:12	belolleda5@guru.smp.belajar.id	13 / 14	Belo Oleda	Guru	13/08/2026
13/08/2026 15:40:12	marlyantimiza@gmail.com	14 / 14	MARLIYANTI, S.P	Guru	13/08/2026
13/08/2026 15:47:31	saritharahap5@guru.smp.belajar.id	14 / 14	Santi Apriani H	Guru	13/08/2026
13/08/2026 15:47:33	karnetu4uyanbulan@gmail.com	13 / 14	Karnetul	Guru	13/08/2026
13/08/2026 15:47:46	nurlumayanih13@gmail.com	14 / 14	Nurul M	Guru	13/08/2026
13/08/2026 15:47:50	sitisalamin84@guru.smp.belajar.id	13 / 14	Siti Salaminah, S.Pd	Guru	13/08/2026

Figure 8. Implementation of the post-test

The 14-item multiple-choice instrument was developed based on the training objectives and the Smart Classroom system components introduced during the program. Before administration, the 14-item multiple-choice instrument underwent content validation through expert review by members of the community service team. The reviewers assessed each item for its relevance to the training objectives, clarity of wording, appropriateness of the content, and alignment with the IoT-based Smart Classroom materials delivered during the program. Items considered unclear or insufficiently aligned with the learning objectives were revised by the team before the instrument was administered to participants. The validation was conducted qualitatively through expert judgment rather than through a statistical content-validity index.

Direct observations were conducted during the training, hands-on practice, system implementation, and mentoring sessions. The observations focused on participants' ability to operate the IoT-based Smart Classroom system, read sensor information, interpret environmental data, understand the information displayed on the LCD, and operate the classroom lighting control function. The observations were used to assess participants' practical ability to utilize the implemented system.

Participant feedback was collected during the training and mentoring activities through questions and answers, discussions, participant responses, and descriptions of difficulties encountered during system operation. The feedback focused on participants' understanding of the system, their experience in operating the system, difficulties in interpreting sensor information, and aspects requiring further assistance.

The observation and feedback data were analyzed descriptively by identifying participants' demonstrated abilities, difficulties encountered during system operation, and aspects requiring additional explanation or mentoring. The qualitative findings were used to complement the quantitative pre-test and post-test results, particularly in describing participants' practical ability to operate the IoT-based Smart Classroom system and utilize the resulting environmental information to support classroom and school facility management. The participants took part in the training, demonstration, hands-on practice, implementation, mentoring, and evaluation activities. The participants and the community service team involved in the program are shown in Figure 9.



Figure 9. Participants and the community service team at SMP Negeri 4 Siak Hulu

The success of the program was evaluated using quantitative and practical indicators. The primary quantitative indicator was the improvement in participants' knowledge, measured by comparing the pre-test and post-test scores. The practical indicators focused on participants' ability to operate the IoT-based Smart Classroom system, read and interpret the information provided by the system, observe classroom environmental conditions, and operate the classroom lighting control function during hands-on practice and mentoring ([Isnanto et al., 2026](#); [Pawana et al., 2025](#)).

Program achievement was determined based on three measurable sources of evidence: (1) changes in participants' pre-test and post-test scores, (2) direct observation of participants' ability to perform basic Smart Classroom system operations, and (3) observation and participant feedback regarding the use of monitoring information for classroom environmental and school facility management. These indicators were used to assess the achievement of the training, implementation, and mentoring activities.

The quantitative data obtained from the pre-test and post-test were analyzed using descriptive statistics. The analysis included the number of correct answers, individual scores, minimum and maximum scores, and mean scores. Individual scores were calculated based on the proportion of correct answers to the total number of questions. Since the evaluation instrument consisted of 14 questions, the score represented the percentage of correct answers. The pre-test and post-test mean scores were then compared to determine the improvement in participants' knowledge following the training, implementation, and mentoring activities.

For objective evaluation, the knowledge indicator was defined as an increase in the mean post-test score compared with the mean pre-test score. The practical operation indicator was defined as participants' ability to independently perform the basic operating procedures of the IoT-based Smart Classroom system after mentoring. The achievement of these indicators was determined from the quantitative score comparison and direct observation of participants' operational performance.

The qualitative data obtained from direct observations and participant feedback were analyzed descriptively. The analysis focused on participants' demonstrated abilities, difficulties encountered during system operation, responses during training and mentoring, and areas requiring further assistance. The qualitative findings were used to strengthen the interpretation of the quantitative results and to describe the practical adoption of the IoT-based Smart Classroom system by the participants.

RESULTS AND DISCUSSION

Results

The results indicate that the community service program was associated with an improvement in participants' understanding of the IoT-based Smart Classroom system. The mean score increased from 81.95% in the pre-test to 95.86% in the post-test, representing a descriptive increase of 13.91 percentage points. The minimum score also increased from 50.00% to 85.71%, while the maximum score remained at 100.00%. These results are summarized in Table 1.

Table 1. Comparison of Pre-Test and Post-Test Results

Evaluation	Participants	Questions	Mean Score (%)	Minimum (%)	Maximum (%)
Pre-Test	19	14	81.95	50.00	100.00
Post-Test	19	14	95.86	85.71	100.00

Figure 10 presents the implemented IoT-based Smart Classroom system and its supporting devices. The system integrates the ESP8266 controller with temperature and humidity sensing, light sensing, motion detection, an I2C LCD display, and a classroom lighting-control component. The implemented system was used as the practical medium during the training, hands-on practice, and mentoring activities.



Figure 10. IoT-based Smart Classroom system and supporting devices

The relatively high baseline pre-test score of 81.95% may indicate that some participants already had basic familiarity with digital technologies or technology-assisted activities before the program. As teachers and school personnel, participants may have encountered digital tools in their professional activities. However, prior experience with IoT-based Smart Classroom technology was not formally measured in this evaluation. Therefore, the relatively high baseline score should be interpreted cautiously and should not be assumed to represent prior competence in IoT technology. Despite the relatively high starting point, the post-test results showed a further increase in performance. The improvement in the minimum score from 50.00% to 85.71% also suggests that participants with lower initial scores showed substantial improvement following the program.

The improvement can be interpreted in relation to the sequence of training, demonstration, hands-on practice, and mentoring activities. The training stage provided participants with the conceptual foundation needed to understand the purpose of IoT technology and its application to classroom environmental monitoring and facility management. The demonstration stage then connected the concepts presented during the training with the actual Smart Classroom system. Participants could observe how environmental information was generated and displayed by the system and how the classroom lighting-control function operated.

Hands-on practice provided an opportunity for participants to translate the concepts introduced during training into practical activities. Participants directly interacted with the implemented system by checking environmental readings, observing sensor responses, reading information displayed on the LCD, and operating the classroom lighting control. This direct interaction helped participants relate the concepts discussed during training to actual classroom conditions. The increase observed at the individual level, together with the distribution of score changes, provides additional evidence of improvement beyond the comparison of mean scores alone. The distribution of individual score changes is presented in Table 2.

Table 2. Distribution of Changes in Participants' Pre-Test and Post-Test Scores

Score Change	Number of Participants	Percentage
Increased	13	68.42%
Unchanged	6	31.58%
Decreased	0	0.00%
Total	19	100.00%

To provide a clearer visual comparison of the overall evaluation results, the mean pre-test and post-test scores are presented in Figure 11. The figure illustrates the increase in the mean score from 81.95% before the program to 95.86% after the training and mentoring activities.

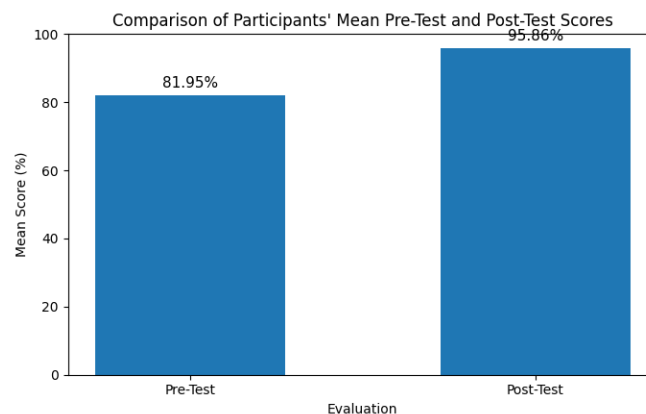


Figure 11. Comparison of participants' mean pre-test and post-test scores

Mentoring provided further reinforcement through repeated practice and guided problem solving. After the initial demonstration and guidance, participants were given opportunities to repeat the basic operating procedures themselves. Following the mentoring activities, all 19 participants were observed performing the basic operating procedures independently, including checking temperature and humidity readings, observing light and motion sensor responses, reading information displayed on the LCD, and operating the classroom lighting control. Participants performed these procedures directly rather than relying solely on demonstrations from the community service team. This observation provides practical evidence that the program supported not only an increase in knowledge but also the development of basic operational skills for using the implemented Smart Classroom system.

The main outcome of the community service program was therefore not simply the introduction of individual hardware components, but the transfer of a practical IoT-based monitoring and control approach to teachers and school personnel. Participants were introduced to the use of environmental information for understanding classroom conditions and to the use of the available control function for classroom lighting management. This practical orientation is relevant to the objectives of the program because the technology was implemented in the partner school and accompanied by training, hands-on practice, and mentoring rather than being limited to the development of a technical prototype.

Discussion

The use of IoT technology for classroom environmental monitoring is consistent with previous studies that have applied connected sensors to monitor parameters such as temperature, humidity, lighting, and occupancy in educational environments (Fidarliyan et al., 2022; Widjaja et al., 2022; Zilni & Wibisono, 2025). However, the contribution of the present program lies primarily in the practical adoption of the technology within a community service setting. The program emphasized the transfer of knowledge and operational skills to school personnel so that the implemented system could be used as a practical tool for classroom monitoring and facility management. This approach is consistent with previous findings (Maryani et al., 2025), which reported the implementation of an IoT-based environmental monitoring solution in a school setting to support the monitoring of temperature, humidity, and lighting for school environmental management.

The sustainability of the implementation depends on the ability of the school to continue using the system after the completion of the community service activities. The observation that all 19 participants were able to perform the basic operating procedures independently provides an initial indication that the school has personnel capable of carrying out routine system operation without relying solely on the community service team. This capacity may support continued use of the system for basic classroom environmental monitoring and lighting control.

However, independent operation should be distinguished from independent technical maintenance. The present program provided participants with experience in basic system operation, but the school's capacity to independently perform long-term technical maintenance was not formally evaluated. Therefore, the current findings support the school's capacity for basic routine operation, but they do not establish its capacity for independent technical maintenance. Sustainable implementation requires the school to designate responsible personnel, conduct periodic checks of the devices and connections, maintain the required power and internet infrastructure, and provide basic troubleshooting procedures. For technical problems that cannot be resolved by school personnel, access to appropriate technical support would also be required.

Implications

The implementation of the IoT-based Smart Classroom program indicates that replication in other schools requires several basic conditions. First, the school should have adequate electrical infrastructure and stable internet connectivity to support the operation of the IoT devices. Second, the required hardware, including the ESP8266 controller, environmental sensors, LCD display, and lighting-control components, should be available and appropriately installed in the classroom. Third, teachers or school personnel should be designated as system users and receive structured training, hands-on practice, and mentoring to develop basic operational skills. Finally, the school should assign responsible personnel for routine system checks and maintenance and establish access to technical support when problems cannot be resolved internally. These conditions can support the practical adoption and continued use of the IoT-based Smart Classroom system in other school settings.

Research Contribution

The main contribution of this community service program is the practical transfer and adoption of IoT-based Smart Classroom technology within a school environment. Rather than focusing solely on the development of an IoT prototype, the program combined system implementation with structured training, hands-on practice, and mentoring for teachers and school personnel. The evaluation also combined quantitative evidence from pre-test and post-test scores with observations of participants' basic independent operation of the implemented system. This approach demonstrates how IoT technology can be introduced through a practice-oriented community service model while maintaining the distinction between immediate learning and operational outcomes and longer-term impacts that require further evaluation.

Limitations

The present evaluation primarily provides descriptive evidence of immediate learning and practical system operation. Although the mean participant score increased from 81.95% to 95.86%, the evaluation used a one-group pre-test-post-test design without a control or comparison group. Therefore, the observed increase in scores cannot be attributed exclusively to the training and mentoring activities, and the findings should be interpreted as evidence of change within the participating group. In addition, the relatively high baseline score may have introduced a potential ceiling effect, whereby participants with high pre-test scores had limited room for measurable improvement in the post-test. The evaluation also did not measure long-term knowledge retention, sustained system utilization, actual energy savings, or long-term technical maintenance performance. Future evaluations should consider the use of a comparison group where feasible, longer-term follow-up, and additional measures of system utilization, maintenance performance, and energy consumption.

Suggestions

Future evaluations should focus on longer-term system utilization, participant knowledge retention, maintenance practices, energy consumption, and the sustainability of the Smart Classroom implementation. Future studies may also examine the frequency of system use, maintenance requirements, and changes in classroom energy consumption using direct measurements. These evaluations would provide additional evidence regarding the long-term usefulness and sustainability of the implemented system.

The system can subsequently be developed from a training implementation into a more sustainable school facility monitoring platform. Future development may include historical data storage, web or mobile dashboards, notifications, additional environmental sensors, and automated control functions. These developments could provide additional data for longer-term monitoring of classroom environmental conditions and future evaluation of facility management and energy use.

CONCLUSION

The findings indicate that the Community Service Program met its immediate objectives of introducing and implementing an IoT-based Smart Classroom system and providing teachers and school personnel at SMP Negeri 4 Siak Hulu with practical knowledge and basic operational skills for classroom environmental monitoring and lighting control. The program combined training, hands-on practice, and mentoring to facilitate participants' direct interaction with the implemented system.

Quantitatively, the evaluation showed an increase in the participants' mean score from 81.95% in the pre-test to 95.86% in the post-test, representing a descriptive increase of 13.91 percentage points. The minimum score increased from 50.00% to 85.71%, while the maximum score remained at 100.00%. At the individual level, 13 of the 19 participants (68.42%) increased their scores, 6 participants (31.58%) maintained the same scores, and no participant showed a decrease.

The practical observations further showed that all 19 participants were able to independently perform the basic operating procedures of the implemented IoT-based Smart Classroom system after the mentoring activities. These procedures included checking temperature and humidity readings, observing light and motion sensor responses, reading information displayed on the LCD, and operating the classroom lighting control. These findings indicate that the program supported short-term knowledge improvement and the development of basic operational skills in using the implemented Smart Classroom system.

The implemented system was used as a practical platform for classroom environmental monitoring and lighting control at the partner school. However, the present evaluation did not directly measure energy savings, improvements in facility-management effectiveness, long-term knowledge retention,

or sustained system utilization. Therefore, no conclusion can be drawn regarding the actual energy efficiency or effectiveness of school facility management resulting from the implementation.

Future community service activities should focus on long-term system utilization, maintenance practices, energy consumption monitoring, and system sustainability. Further development may include historical data storage, web or mobile dashboards, notification mechanisms, and automated control functions to support continued use of the system at the partner school.

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AUTHOR CONTRIBUTION STATEMENT

AI served as the principal investigator, coordinating the planning, implementation, field activities, data collection, analysis, and preparation of the manuscript. AS, GS, HE, ID, JR, and RS contributed to the implementation of the community service activities, participant training and mentoring, system demonstration and testing, data collection, documentation, and manuscript refinement.

AI DISCLOSURE STATEMENT

During the preparation of this work, the authors used ChatGPT (OpenAI) to assist with language improvement, readability, and manuscript refinement. The authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

CONFLICT OF INTEREST

The authors declare that there is no any conflict of interest related to the publication of this article.

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