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Preface

The 14th International Conference on Information and Education Technology (ICIET 2026) was held in in Koriyama, Japan, from April 17 to 19, 2026. It was co-sponsored by Nihon University and IEEE, co-hosted by Shonan Institute of Technology, Okayama University, Japan, etc.

Since its inauguration, ICIET has maintained a steady and healthy development momentum, with successful editions held in Tokyo (2017), Osaka (2018), Aizu (2019), a virtual format (2020), Okayama (2021), Matsue (2022), Fujisawa (2023), Yamaguchi (2024), and Fukuyama (2025). Obviously, this conference maintains a good momentum of steady development these years. Since its inception, ICIET has consistently invited renowned experts to deliver keynote and plenary speeches focusing on cutting-edge topics in information and education technology. The core objective of the conference is to bring together leading researchers, experts, and scholars worldwide to share their latest research findings, exchange insights, and address critical open issues in the field of information and education technology.

The proceedings of ICIET 2026 compile over 130 full papers, covering a broad spectrum of research areas in information and education technology, including but not limited to: Generative AI in Teaching and Learning: Applications and Content Creation; Intelligent Tutoring Systems and Human-AI Collaborative Learning; Learning Analytics and Educational Data Mining, Natural Language Processing and Computer Vision in Education; Immersive Technologies and Game-Based Learning in Education; Programming Education and Computational Thinking Development; and Innovative Pedagogical Models and Inclusive Design in Education in the Digital Era.

The high quality of the papers included in these proceedings is attributed to the rigorous peer review process. We sincerely appreciate the peer reviewers for their valuable time and constructive comments, which greatly helped the authors refine their manuscripts. We would like to thank all authors who submitted their research work, as their contributions were fundamental to the success of the conference. As you engage with these proceedings, we encourage you to submit your research proposals to ICIET 2027, which is scheduled to be held in Osaka, Japan, from April 9 to 12, 2027.

Finally, we would like to reiterate our gratitude to all individuals and institutions that contributed to the success of ICIET 2026. May this collection of papers bring new insights and opportunities to researchers, educators, and practitioners worldwide.

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Implementation and Benefits of a Remote Access-Based Physical PLC Laboratory to Increase the Flexibility and Intensity of Vocational Higher Education Students' Practice

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***Abstract*—In a vocational program at a higher education institution, lab sessions dominate teaching and learning activities. Ideally, the ratio of students to equipment is 1:1. However, due to the high price of the equipment, the ratio is rarely reached. This leads to rigid schedules and equipment queues. The gap between theoretical understanding and hands-on experience in controlling real hardware poses a significant challenge. This research aims to implement and analyze the benefits of a remote-access-based physical PLC laboratory to increase the flexibility and intensity of student practice. The developed system consists of physical PLC modules integrated with simple I/O modules, remotely accessible via the Internet. The system proves effective in enhancing learning flexibility (24/7 access), the intensity of self-directed practice, and laboratory asset utilization. Furthermore, it bridges the gap between software simulation and hardware reality. It is concluded that a hardware-based remote laboratory is a feasible and effective solution for democratizing access to practical engineering education, serving as a significant enhancer to traditional hands-on learning experiences. Recommendations for future development include adding variety to practical modules and replicating the model for other technical disciplines.**

Keywords—remote laboratory; full-time access; flexible learning; e-learning; PLC laboratory

I. INTRODUCTION

Vocational higher education emphasizes practical skills and theoretical understanding. In the Engineering of Mechatronics Technology Department, especially in the Programmable Logic Controllers (PLCs) subject, besides knowing the concept and the theory of the PLCs, students also need to master how to use them practically. In this field of study program, PLC programming competency is very important. More than 70% of manufacturing industries are still using PLCs for their automation. PLCs are industrial standard equipment. Therefore, the price is still considerably high. Looking at those two major facts, access to conventional PLC laboratories often has several problems, such as time and space constraints, a rigid schedule, and student flexibility in using the lab. The number of PLCs in the laboratories is usually limited compared to the number of students. The students should work as a group and reduce the intensity of individual practice. This situation is getting worse during emergencies, such as pandemics, which demand robust, ubiquitous, and practical learning solutions. Simulation-Hardware Gap: Simulator software (such as TIA Portal), while valuable for logic learning, does not provide real-world experience in handling the electrical characteristics, noise, and dynamic behaviour of real hardware [1]. The teaching-learning process in the laboratory should be able to provide a nearly real experiment environment for the student [2].

Based on these challenges, this study proposes and implements a solution in the form of a physical PLC laboratory based on remote access. Using a remote PLC Lab, students will be able to access the PLC after normal class hours without having to be in the laboratory. A remote laboratory helps to improve the learning process for the student to reach the learning outcomes without adding formal scheduled extra time of teaching and learning [3]. Conventional laboratories are still important. However, a remote laboratory is a good solution in certain situations [4]. One of the most significant contributions of the remote laboratory is the improvement of self-study for learners [5]. A remote laboratory gives more opportunities and freedom to the students to perform their experiments [6]. Students can still access the PLC from home in the evenings to work on their assignments or to practice. To facilitate and equalize use for students, a simple usage schedule can be created. With this PLC Lab can be accessed at any time for 24 hours a day and 7 days a week. The purpose of this study is firstly to design the technical implementation of a remote PLC laboratory consisting of a Siemens S7-1200 PLC device equipped with a Human-Machine Interface (HMI) device. To access the PLC input channel when testing programs remotely using an ESP32 microcontroller based on MQTT. Meanwhile, to monitor the PLC output channel connected to the indicator lights, a web-based camera will be used. Second, the advantages of this remote laboratory system will be analysed for efficiency and increased utility. Third, the system performance will be evaluated in bridging the gap between using only simulation tools and practical experience using direct hardware, using remote laboratory tools.

II. METHOD

This research begins with the system design stage, technical implementation, and evaluation. The system design includes

mechanical, electronics, and application programs design. Next, the system is assembled and tested. The evaluation phase will collect data on system performance and user satisfaction, in this case, students operating the PLC module remotely.

A. System Design

The system is designed with a client-server architecture. The physical laboratory unit ("server") is located on campus, while students ("clients") can access it from remote locations. The system consists of four main subsystems:

1. Core Control Subsystem (PLC & HMI): A Siemens S7-1200 PLC is used as the main controller, and a 7-inch Siemens HMI panel is used for local display.
2. Remote I/O Subsystem consists of Virtual Digital and Analog Input. Digital Inputs: Physical inputs (buttons, sensors) that are replaced by virtual interfaces. For digital inputs (buttons), an ESP32 module is connected to an MQTT broker. Students access the PLC's input using the MQTT panel that is installed on their mobile phone. Using buttons on the MQTT panel, students can control mechanical relays connected to the ESP32 via MQTT. The mechanical relays then activate the PLC's digital input module. Analog Input: Physical potentiometers are connected to RC servo motors whose position is controlled remotely using the ESP32. The servo angle values (set by the student from the MQTT panel) are converted into analog values that are sent to the PLC.
3. Access and User Interface Subsystem: A host computer in the lab is connected to the PLC via an Ethernet cable and runs Siemens TIA Portal (for programming) and AnyDesk (for remote access) software. Students access this host computer remotely using the AnyDesk client. They can program the PLC through the TIA Portal running on the host computer and download the program to the PLC.
4. Visual Feedback Subsystem: A webcam is strategically positioned to monitor the PLC-HMI panel and indicator lights. The video from the webcam is previewed on the server monitor that accessed by students remotely using the AnyDesk client.

The mechanical design of the system consists of a PLC-HMI frame module and the webcam support. The frame is made from a 20x20mm aluminium profile to hold the PLC, Touchscreen panel box, and the I/O box. The touchscreen panel box is used to hold the 7-inch Siemens HMI. The I/O box is used to keep the ESP-32 microcontroller, a relay module that is used to switch the digital input, and the servo-potentiometer for the analog input feeder of the PLC. Fig. 1. Block diagram of the remote PLC laboratory systemis shown in Fig. 1.

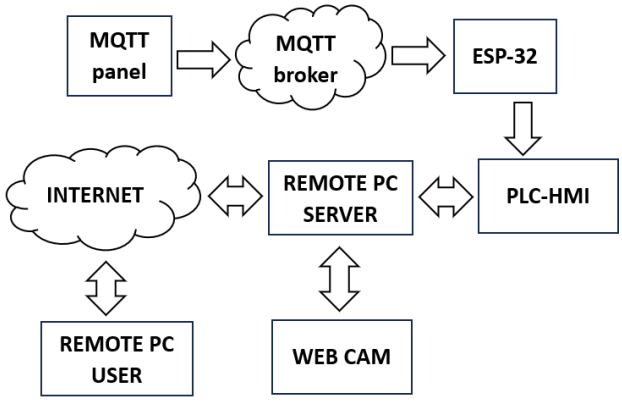

Fig. 1. Block diagram of the remote PLC laboratory system.

B. Technical Implementations

The PLC is connected through a computer in the laboratory. To access the input of the PLC, several mechanical relays are controlled remotely using ESP32 based IoT system that able to be controlled by the students from home using an MQTT panel installed on their mobile phone. A simple queue management system is implemented using Google Spreadsheet so anybody will be able to check it. Fig. 2 shows the MQTT panel from the student's view.

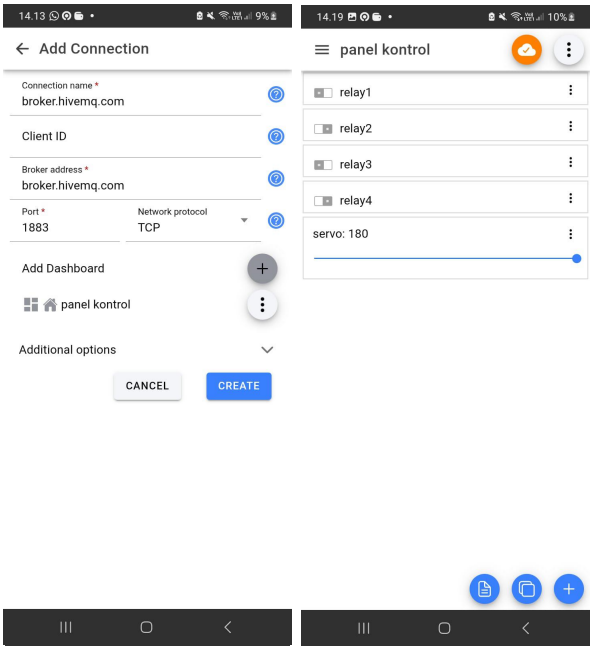

Fig. 2. MQTT panel on the students' mobile phone

The electronic wiring diagram of the ESP32, RC Servo Motor, and the relay module is shown in Fig. 3.

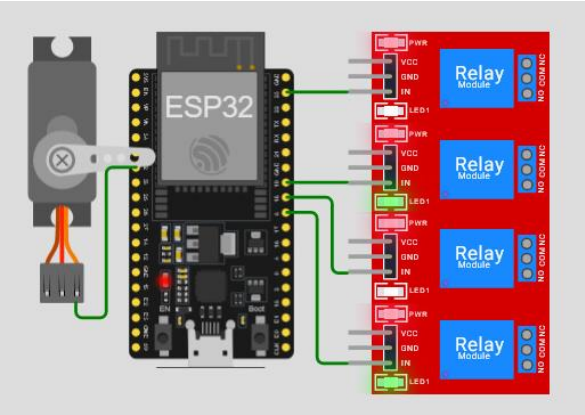

Fig. 3. Electronic wiring diagram of the ESP32, RC Servo Motor, and the relay module .

C. Evaluation

The evaluation of the system's benefit are conducted through:

1. System Performance: Latency from the MQTT commands to the PLC's responses is monitored from the video.
2. Surveys and Interviews: Thirty students fill out questionnaires to check the access perceptions of the system's flexibility, contribution to material understanding, and the ease of use. A 5-point Likert scale was utilized. Table 1 shows the interpretation of the response average.

TABLE I. QUESTIONNAIRE DATA INTERPRETATION

Scale	Interpretation
$x \geq 4.0$	Very satisfied
$3.0 \geq x \leq 3.9$	Satisfied
$2.0 \geq x \leq 2.9$	Neutral
$1.0 \geq x \leq 1.9$	Dissatisfied
$x \leq 0.9$	Very dissatisfied

III. RESULTS

The results of this study can be seen from three things, namely the level of implementation success, access intensity, and user response. The details of each indicator are as follows:

Implementation success: The remote PLC laboratory system has been successfully implemented and is running stably. Functional testing demonstrated that all components operate as designed:

1. Students can connect to the host computer via AnyDesk to program the PLC with the TIA Portal and download programs.
2. The web interface for I/O control (buttons and servos) responds within < 500ms from user command to execution in the PLC.
3. Video streaming from the webcam provides clear, real-time visual feedback with a latency of approximately 1-2 seconds.

Access intensity: Access log data from the one-month trial period showed significant improvements:

1. 24/7 Access: Approximately 20% of the total lab sessions (additional assignment) were conducted outside of conventional laboratory hours (evenings and weekends).
2. Increased Individual Intensity: The average lab time per student per week increased from 4 hours (in the conventional, scheduled setting) to 5 hours.
3. Asset Utilization: A single PLC can be used by up to four different students in a single day.

The survey results showed positive responses:

1. Flexibility of time and location: 4.7.
2. Ease of repetition and independent experimentation: 4.5.
3. Contribution of the system to understanding the relationship between the program and real-world hardware behavior: 4.6.
4. The quality of visual feedback from the webcam was rated as adequate: 4.0, with a note of a desire for higher resolution and frame rate.

Based on Table 1, all the students are very satisfied with the system. The interview and the questionnaire results also show that the students find it very useful and helpful for them to learn PLC programming. By following the tutorial, the students can freely practice the material and test it without pressure.

IV. DISCUSSION

The limitation of the availability of PLCs can be overcome using this system. The problem actually starts from the limitation of the working hours in the lab. But, using this system, students can work anytime from anywhere connected to the Internet. This method offers a low-cost solution. The reliability is supported by the robust industrial-grade PLC and communication software. Nonetheless, there are still some light and low cost component, such as the microcontroller and some interfacing components on the system.

A. Bridging the Simulation-Hardware Gap

This method gives a solution to bridge the gap between simulation and real-world practice. Student able to observe physical output, such as the pilot lamp and HMI preview of the student's work. By using this system, the teaching learning process is still able to give the students real experience in PLC programming that a simulator cannot give.

B. Democratizing Access and Accelerating Learning

Eliminating time and place constraints, the system can democratize access to the PLC's hardware. The more opportunities to practice with hardware, the more students'

competencies develop. A vocational program is well known for its hands-on oriented study.

C. Challenges and Limitations

Some points to be considered in this research are: (1) Hardware response: A remote access of hardware that includes feedback will take some time to get the response since the first action from the student. This timing in response to the student's action is very important. A pure real-time response is impossible, but an immediate response can be a key for the student in enjoying the remote hardware. (2) Reliability: The network quality and the robustness of the circuit will determine the reliability. (3) Physical Sensor Limitation: This system accommodates accessing the PLC input digital and analogue using MQTT-based IoT. However, there are still many physical sensors that cannot be handled in this remote hardware lab system.

V. Conclusion and Recommendation

From the results and discussion above, it can be concluded as follows:

A. Conclusions

After all, it can be concluded that:

1. A remote PLC Laboratory using a Siemens S7-1200 controller, HMI, ESP32 embedded system, MQTT-based IoT, and a remote desktop software has been successfully developed.
2. The system can work the whole time, 24/7 access, which helps the student a lot to master the competency of PLC programming.
3. The system successfully bridges the gap between the simulation environment and real hardware, thereby enriching the learning experience and improving the conceptual understanding and practical skills of vocational education students.

B. Recommendations

Recommendations for further studies are:

1. Content Development: Adding a variety of practical modules to cover more industrial actors (e.g., stepper motors, miniature conveyor belts, sorting systems) and complex programming scenarios (PID, network communication).
2. Replication and Adaptation: This model can be replicated for other disciplines such as power electronics, microcontrollers, or instrumentation, with appropriate hardware and remote interface adjustments.
3. Technology Enhancements: Explore the use of specialized Virtual Network Computing (VNC) technology, integrate more interactive monitoring dashboards, and enhance video streaming quality with pan/tilt/zoom controllable cameras.
4. Hybrid Learning Model: This system should be integrated as part of a hybrid learning model, where remote sessions complement (but do not completely replace) hands-on lab sessions for skills requiring direct wiring and installation of physical components..

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