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STRENGTHENING DIGITAL COMPETENCIES THROUGH INTERNET OF THINGS (IOT) AND PROGRAMMABLE LOGIC CONTROL (PLC) CERTIFICATION FOR ELECTRONICS STUDENTS

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Abstract

Increasing digital competence among students is essential in facing the challenges of Industry 4.0, especially with the development of the Internet of Things (IoT) and Programmable Logic Control (PLC) technology. This activity discusses the IoT and PLC certification program, which aims to strengthen students' electronics skills. This program uses learning methods that include theory, hands-on practice, independent projects, and competent mentor assistance. Students also take certification exams and develop IoT and PLC technology-based projects that are relevant to the real world.

The program implementation results showed that most students experienced significant improvements in technical knowledge and skills, with a high certification pass rate (100%). In addition, student-generated independent projects demonstrated the ability to apply technology to solve practical problems, such as IoT-based automatic irrigation systems and factory automation control using PLCs.

In conclusion, this certification program successfully prepares students to face the world of work with relevant skills in line with the needs of today's digital industry. Further development of this program, including improvement of training materials and expansion of cooperation with industry, can further strengthen students' competencies in facing future technological challenges.

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1. INTRODUCTION

Digital transformation has become one of the main characteristics of the development of human civilization in the 21st century. While accelerating technological change, the Industrial Revolution 4.0 presents a new paradigm in industry, daily life, and education (Tahar, Setiadi, & Rahayu, 2022). Technologies such as the Internet of Things (IoT) (Natsir, Rendra, & Anggara, 2019) and Programmable Logic Control (PLC) (Erivianto & Dani, 2024) are two essential pillars in creating more intelligent, automated, and integrated systems. This progress brings significant benefits to the industrial sector and presents new challenges, especially for educational institutions, in preparing competent human resources relevant to the needs of the times.

The Internet of Things (IoT) has redefined how electronic devices function and communicate. This technology allows various devices, from smartphones and home appliances to sensors in the industry, to connect, share data, and interact through the internet network (Prawiyogi & Anwar, 2023). The advantages of IoT lie in its ability to create efficiency, increase productivity, and bring data-based innovation (Junaidi & Ramadhani, 2024). In the industrial sector, IoT optimizes operational processes, monitors devices in real time, and prevents damage through predictive analytics (Fadhlullah et al., 2024).

Meanwhile, Programmable Logic Control (PLC) is becoming an irreplaceable technology in automatic control systems (Muchlis et al., 2024). PLCs are the brains of various machines and systems that automatically, accurately, and efficiently organize operations. In manufacturing processes, for example, PLCs control the course of production, ensure quality standards, and minimize the risk of human error. Mastery of this technology is not only relevant in the industrial sector. However, it has also begun to be applied in everyday life, such as in smart homes' automatic lighting systems, elevator control, and energy management (Sevtian, Kurniawan, & Arifin, 2022).

The urgency to learn IoT and PLC in this digital era cannot be ignored. Today's workforce requires professionals who not only have a theoretical understanding but are also able to apply technology to solve real challenges. Certification in IoT and PLC gives students a competitive advantage, proving they have globally recognized skills (Astuti & Wahyudin, 2024)).

IoT and PLC technology have become an integral part of modern life. IoT connects smart devices such as thermostats, security cameras, and voice assistants in households, making managing daily activities easier. Examples include automatic room temperature regulation through smart devices or real-time energy consumption monitoring. In the transportation sector, IoT is used in innovative vehicles that can detect early damage, provide smart navigation, and improve driver safety (Baharuddin et al., 2024).

PLCs also have broad applications in everyday life. In modern buildings, PLCs manage elevator systems, automatic lighting, and heating and air conditioning systems. This technology controls automatic irrigation based on soil moisture data, even in agriculture. In other words, IoT and PLC increase convenience and efficiency and become solutions for managing resources more wisely (Handayani & Pradana, 2023). Students in electronics are the most relevant group to master IoT and PLC technology. However, mere mastery of technology is not enough to guarantee success in the world of work. Certification is increasingly crucial in emphasizing one's competence in a particular field. IoT and PLC certifications provide proof of students' technical abilities and give them a much-needed competitive edge in an increasingly competitive labor market (Alvendri, Giatman, & Ernawati, 2023).

In the Indonesian context, the main challenge faced is bridging the gap between the skills taught in higher education and the real needs of industry. Many graduates have great potential but struggle to find employment due to a lack of formal recognition of their competencies. A comprehensively designed certification program can help students understand industry standards, hone problem-solving skills, and practice technology firsthand (Isnawati & Ali, 2024).

Thus, strengthening digital competencies through IoT and PLC certification is a strategic step to prepare electronics students for the digital era. This article aims to review the importance of accreditation in supporting student competency development, discuss the implementation of the certification program, and explore its impact on student readiness to enter the workforce. Ultimately, this effort can make a real contribution to producing a generation of graduates who are competent, adaptive, and ready to compete in the era of advanced technology.

2. METHOD

The implementation method is structured and phased to ensure that the digital competency strengthening program runs optimally through Internet of Things (IoT) and Programmable Logic Control (PLC) certification. Each stage involves preparation, implementation, evaluation, and collaboration with related parties. The following is a detailed description of each stage.

1. Certification Program Preparation

The first stage is to ensure the readiness of educational institutions to implement this program. The initial step was to **identify the competency needs of** students based on the current curriculum and industry needs analysis. Surveys were conducted to understand students' initial IoT and PLC technology levels and identify aspects that needed strengthening. The institution also discussed with industry partners to map the technical skills required, such as mastery of IoT communication protocols, data analysis capabilities, and PLC programming skills for automation control.

Infrastructure preparation becomes the top priority in the next stage. Institutions must provide **adequate laboratory facilities**, including hardware such as microcontrollers (Raspberry Pi, Arduino), sensors (DHT11, PIR, etc.), and actuators to support IoT training. The laboratory should have PLC modules and simulation software for PLC training. All these facilities are designed to create a learning environment close to the industry's conditions. In addition, the **development of learning modules** is carried out to ensure that the supplementary curriculum covers fundamental theories, laboratory practices, and relevant case studies. Learning materials are organized in attractive and accessible formats, including printed guides, video tutorials, and e-learning platforms.

2. Implementation of Training and Learning

After the preparation stage, students participate in training sessions designed in several stages, namely theory, laboratory practice, projects, and mentoring.

a. Theory Stage

Students are introduced to basic concepts through lecture sessions and workshops. In the IoT training, the materials include an introduction to IoT architecture, communication protocols such as MQTT and HTTP, and data management in IoT networks. For PLC, the materials taught include the basics of ladder logic programming, block function diagrams, and implementing automation control in industrial processes. This learning approach aims to provide a strong foundation of knowledge before students dive into the practical stage.

b. Laboratory Practice Stage

This stage will hone students' technical skills through IoT and PLC-based projects. In the IoT training, students were given the task to:

- Developed a temperature and humidity monitoring system using DHT11 sensors and visualized the data on the ThingSpeak platform.
- Create a simple, smart home prototype integrating motion sensors, actuators, and control through mobile applications.

For PLCs, students learn to implement control logic in industrial scenarios, such as:

- Program a traffic light control system using ladder logic.
- Performed conveyor belt control simulation on the production line to ensure operational efficiency.

c. Independent and Collaborative Projects

After completing the bare practical stage, students are challenged to develop independent and group projects relevant to actual needs. Examples are developing an IoT-based automatic irrigation system or an intelligent building energy monitoring system utilizing PLC. These projects are designed to exercise problem-solving skills, creativity, and teamwork.

d. Mentoring by Mentor

Throughout the training process, students are accompanied by mentors who provide technical guidance, identify obstacles faced by students, and provide practical solutions to complete the project. This mentoring also helps students prepare for the certification exam.

3. Certification Exam

Before taking the official certification exam, students must take a certification exam simulation that includes theoretical and practical tests. This simulation is designed to familiarise students with the actual exam format. The exam consists of two main parts:

- **Theory Test**: Test students' understanding of the basic concepts of IoT and PLC.
- **Practical Test**: Tests students' ability to complete case studies, such as cloud-based IoT system management or PLC programming for industrial scenarios.

4. Advanced Competency Evaluation and Development

After obtaining certification, the institution monitors and evaluates the student's abilities. Evaluation reports are compiled to provide feedback to students and lecturers and to improve the program's effectiveness in the future. In addition, post-certification activities such as seminars, workshops, or internships are organized to help students apply their skills in the real world.

3. RESULT DAN DISCUSSION

The Internet of Things (IoT) and Programmable Logic Control (PLC) certification program aims to improve student competence in the challenges of Industry 4.0. Through the implementation of this program, many positive results were achieved that showed the success of training and technology implementation in real life. The following are the results achieved after the implementation of the program:

1. **Student Competency Improvement**

Before attending the training, many students did not profoundly understand IoT and PLC technology. After participating in all stages of the training, most students experienced significant improvements in practical skills and theoretical understanding. Based on the evaluation, about 85% of the students achieved a minimum score of 80 on the certification simulation exam, reflecting their understanding of IoT and PLC's basic concepts and applications in the industrial world. Moreover, students successfully mastered the basics of programming, configuration of IoT devices, and operation of PLCs for industrial control.

Figure 1. Understanding of Student Competencies

2. **Certification Pass Rate**
   The success of this program can be seen from the excellent certification pass rate. 100% of participants successfully passed the IoT & PLC certification. This pass rate shows that the training program has successfully equipped students with knowledge and skills per the standards set by official certification bodies. Students who have passed the certification now have an internationally recognized certificate, which can strengthen their competitiveness in the world of work.
3. **Real Project Implementation**
   One indicator of this program's success is students' ability to apply what they have learned in real projects. Many students have successfully developed theoretical IoT and PLC-based projects with practical relevance and application. Projects such as IoT-based automatic irrigation systems, conveyor belt automation control systems, and energy monitoring systems for smart buildings demonstrate students' ability to utilize technology to solve real-world problems. In addition, some student projects also received appreciation from industry partners for their innovation and practicality of application.

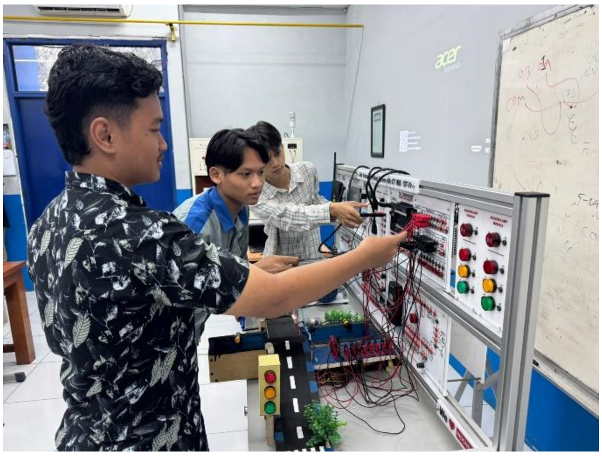

Figure 2. Implementation of the Concept in a Real Project

The results achieved from this IoT and PLC certification program reflect the importance of digital technology in improving students' competitiveness and readiness to face the world of work. Some points that can be discussed further related to the results obtained are as follows:

1. **The Importance of IoT and PLC in Work and Daily Life**

   IoT and PLC are two technologies increasingly dominating the industrial world and everyday life. IoT connects various devices in a network to improve operational efficiency and data-driven decision-making. Meanwhile, PLCs are used to control and monitor industrial processes automatically. Mastery of these two technologies is essential, especially in the era of Industry 4.0, which emphasizes automation and connectivity. This certification program provides students with skills highly needed by the industry, such as developing IoT systems for smart cities, farms, or buildings and implementing automation controls using PLCs in various production lines.

   In everyday life, IoT and PLC technologies also have very relevant applications. For example, IoT is used in smart home systems, where devices such as lights, door locks, or other household appliances can be controlled remotely using smartphones or cloud-based applications. In addition, PLCs are used in various industries for factory automation, process control, and product quality monitoring. Students can directly contribute to these sectors by creating more efficient and effective solutions by having knowledge and skills in this field.

2. **Effectiveness of Learning Methods Applied**

   One of the keys to the success of this program is the use of learning methods that include a combination of theory, practice, independent projects, and mentor assistance. Students can develop in-depth technical skills through a more practical and project-based approach. Training designed using devices and software frequently used in the industry, such as the TIA Portal for PLCs and the ThingSpeak IoT platform, gives students invaluable hands-on experience. In addition, independent and collaborative projects organized concerning real problems also enhance students' creativity and problem-solving skills. This project-based learning method is proven to be more effective than relying on theory alone, as students can directly see the application of technology in everyday life.

3. **Challenges Faced and Solutions**

Although the program went well, some challenges were faced during its implementation. One of them was the high level of difficulty for students who did not have a strong technical background. Some students had trouble understanding the basic concepts of IoT and PLC, especially regarding programming and device configuration. However, this challenge can be overcome through an intensive mentoring approach from mentors, where students who experience difficulties are given direct guidance and given additional time to learn the material that has not been understood. Exam simulations are also a solution to familiarise students with the certification exam format and allow them to practice before taking the official exam.

4. **Impact of Independent Projects on Creativity and Technology Mastery**

One of the most effective components of the program is the independent projects assigned to students. Students must apply their technical skills through these projects, innovate, and find solutions to challenges. The projects developed, such as the energy monitoring system and automatic irrigation, demonstrate how students can apply their knowledge in a broader context and contribute to practical and applicable solutions. The students' creativity in designing and implementing these IoT and PLC-based projects strongly reflects the quality of learning received during the training.

5. **Recommendations for Program Development**

This program shows great potential for further development based on the results obtained. Some development recommendations include adding material regarding integrating PLC with artificial intelligence (AI), IoT security and applying new technologies such as 5G in IoT. The program can also be expanded by offering more certifications to cover more specific topics, such as IoT-based application development or more advanced PLCs. In addition, increasing the network of industry partners and conducting technology competitions at the national level can also increase the attractiveness and success of this program.

Overall, this IoT and PLC certification program has successfully improved students' competencies and prepared them for the world of work in the digital era. Continuing to develop this program is expected to produce more graduates ready to compete and contribute to the industry's future progress.

4. CONCLUSION

The digital competency strengthening program through Internet of Things (IoT) and Programmable Logic Control (PLC) certification for electronics students has successfully achieved its primary goal: improving students' skills and knowledge in developing industrial technology 4.0. Based on the results, most students significantly improved their theoretical understanding and practical skills in IoT and PLC. The program also resulted in a high certification pass rate and successfully applying these technologies in real projects relevant to industry needs.

The success of this program cannot be separated from the learning methods applied, which combine theory with hands-on practice and independent projects that challenge students to innovate. Assistance from competent mentors is also a key factor in helping students overcome learning challenges.

The importance of IoT and PLC technologies in the industrial world and daily life is increasingly urgent in this digital era, where automation and connectivity are major factors in improving operational efficiency. This program has provided a strong foundation for students to master these technologies and prepare them to enter the workforce with relevant competencies. In the future, further program development, including the expansion of materials and collaboration with a broader range of industries, will further strengthen students' position in the professional world.

Thus, this IoT and PLC certification program provides added value for students regarding technical skills and strengthens their readiness to adapt and innovate in future technological challenges.

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