

Open PLC : an Open Source Solution For Training Of Non Maintenance Staff

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ABSTRACT

Programmable Logic Controllers (PLCs) are essential in modern industrial automation and Industry 4.0 environments. However, in many vocational institutions and industrial training centers, PLC access is limited primarily to maintenance departments due to high hardware costs, proprietary software licensing, and restricted system flexibility. This limitation reduces opportunities for non-maintenance staff, students, and interdisciplinary engineering practitioners to develop practical automation competencies. To address this gap, a community service program was conducted at Akademi Komunitas Toyota Indonesia, Karawang, utilizing Open PLC-an open-source, IEC 61131-3-compliant PLC platform-as a low-cost and flexible training solution. The program involved structured workshops, hands-on practical sessions, and project-based learning activities using affordable hardware such as Arduino and Raspberry Pi. Participants were trained to design, simulate, and implement basic control systems, as well as integrate PLC logic with IoT and simple SCADA environments. The results demonstrate that Open PLC effectively improves participants' understanding of PLC programming concepts and enhances their practical skills in automation system development. The open-source nature of the platform reduces financial barriers while enabling broader experimentation beyond maintenance-oriented applications. This initiative shows that Open PLC can serve as an accessible and sustainable training tool to expand industrial automation competencies across non-maintenance domains.

Keywords: Community Service; Industrial Automation Education; Non-Maintenance Control System Development; OpenPLC; Open-Source PLC Training

INTRODUCTION

Programmable Logic Controllers (PLCs) are a fundamental component of modern industrial automation, widely used to control machinery and processes in manufacturing, energy distribution, transportation systems, and water treatment facilities (Bolton, 2015; Wei, 2025). Their ability to execute deterministic and reliable control logic in real time makes PLCs indispensable in Industry 4.0 environments, where automation, digital integration, and system optimization are critical (Shelke et al., 2008). Consequently, PLC programming and control system development have become mandatory competencies for engineering and technical students, as well as for engineers involved in system development, research, and innovation beyond traditional maintenance roles (Adaptable Education: The Importance of PLC Training in TechEd - Mechatronics Training, n.d.; The Role of Standard Work in the Toyota Production System - Shinka Management, n.d.; Shelke et al., 2008). Despite their importance, the adoption of PLC technology in educational institutions and non-maintenance engineering domains faces significant challenges. First, commercial PLC

systems require substantial financial investment, including hardware costs, proprietary software licenses, peripherals, and recurring maintenance expenses. These costs pose a serious burden for educational institutions, particularly those operating under limited funding, and restrict large-scale hands-on training (Alphonsus et al., n.d.; Eduardo O. Hernandez & Darwin D. Banzon, 2025; Iyaomolere et al., 2025). Second, most commercial PLC platforms rely on proprietary programming environments that limit interoperability and confine users to vendor-specific ecosystems, reducing adaptability across different industrial platforms (Cai, 2025; Maciel et al., n.d.). Third, restricted access to system configurations and source code limits flexibility, experimentation, and integration with open-source tools, IoT devices, and simulation platforms, which are increasingly important for modern control system development and research (Iyaomolere et al., 2025; Mohamed et al., 2023b). Finally, budget constraints in academic institutions often result in limited access to PLC hardware, leading to theory-oriented instruction with insufficient practical exposure (Koondhar et al., 2023; Mohamed et al., 2017). To overcome these barriers, open-source PLC platforms such as OpenPLC offer a promising alternative (Mohamed et al., 2023a). OpenPLC directly addresses issues of cost, proprietary restrictions, and limited flexibility, while enabling PLC-based development not only for maintenance departments but also for education, research, and interdisciplinary system development. This study aims to present OpenPLC as an accessible and scalable solution for PLC education and non-maintenance control system development, emphasizing its role in bridging the gap between theoretical knowledge and practical automation skills.

METHODE

This study adopts a qualitative-descriptive research design, combining a structured literature review with conceptual and practical analysis to support community-oriented PLC training initiatives. The scope focuses on PLC education and control system development using open-source platforms, emphasizing OpenPLC as an accessible alternative to commercial PLC systems. The objects of analysis include educational PLC implementations, low-cost PLC trainer systems, and open-source automation platforms reported in recent academic and technical literature (e.g., Iyaomolere et al., 2025; Hernandez & Banzon, 2025; Mohamed et al., 2023a).

Primary materials consist of peer-reviewed journal articles, conference proceedings, and technical reports published within the last five years, supplemented by foundational references where necessary (Bolton, 2015; Folgado et al., 2024). Data collection was conducted through systematic searches of academic databases and reputable online sources using keywords such as *PLC education*, *OpenPLC*, *industrial automation*, and *open-source control systems* (Alphonsus et al., 2016; Wei, 2025).

The service method integrates Participatory Action Research (PAR) and Service Learning (SL) principles to ensure that training programs are designed collaboratively with

participants, grounded in prior empirical evidence, and tailored to actual needs. Activities include workshops, hands-on practical exercises, and project-based learning, allowing participants to actively design, test, and implement PLC control logic using OpenPLC on low-cost hardware such as Arduino and Raspberry Pi (Cai, 2025; Mohamed et al., 2017).

Analysis involved identifying recurring challenges associated with commercial PLC adoption, evaluating the features and flexibility of OpenPLC, and assessing its applicability for educational and non-maintenance development contexts (Koondhar et al., 2023; Sehr et al., 2020). Findings were interpreted by synthesizing insights from multiple sources and relating them to current trends in Industry 4.0-oriented automation education, thereby informing the design of effective and scalable community service programs.

RESULT AND DISCUSSION

The analysis reveals that OpenPLC effectively mitigates the major barriers associated with traditional PLC education and development. From a cost perspective, OpenPLC eliminates licensing fees and operates on low-cost hardware platforms such as Arduino, Raspberry Pi, and standard personal computers, significantly reducing financial constraints for institutions and development teams (Mohamed et al., 2023a; Sehr et al., n.d.). This affordability enables broader access to hands-on PLC training and experimentation. In terms of flexibility, OpenPLC supports the IEC 61131-3 standard and provides full access to source code and system configurations. This openness allows users to explore internal PLC mechanisms, customize control logic, and integrate OpenPLC with IoT devices, SCADA systems, and simulation environments—capabilities that are often restricted in proprietary PLC platforms (Iyaomolere et al., 2025). Such features are particularly valuable for non-maintenance departments, including research and development units, where innovation and system integration are essential. Furthermore, OpenPLC's hardware independence and scalability facilitate widespread deployment across classrooms and laboratories, ensuring equitable access to practical learning experiences. This capability addresses the imbalance between theory and practice frequently observed in PLC education and enhances student readiness for industrial automation roles (Eduardo O. Hernandez & Darwin D. Banzon, 2025; Iyaomolere et al., 2025). Overall, the findings demonstrate that OpenPLC serves not only as an educational tool but also as a development platform for modern, connected control systems aligned with Industry 4.0 requirements (Folgado et al., 2024; Wei, 2025).

Benefit of OpenPLC

OpenPLC provides a low-cost and flexible alternative to commercial PLC systems for education and system development. As an open-source platform, it eliminates licensing fees and runs on affordable hardware such as Arduino, Raspberry Pi, and personal computers. OpenPLC supports the IEC 61131-3 standard, allowing users to learn industry-relevant PLC programming without being tied to proprietary software. Full access to source code enables

experimentation, customization, and integration with IoT and SCADA systems. These features make OpenPLC suitable for hands-on learning, research, and control system development beyond traditional maintenance applications

Table 1. Commercial PLC(A) and OpenPLC(B)

Platform	Cost	Openness	Flexibility
A	High	Proprietary	Limited
B	Low	Open Source	High



Figure 1. OpenPLC Sharing to Non Maintenance Staff

Trainee Impression after Training OpenPLC

Trainees reported positive impressions after participating in OpenPLC-based training. Most participants indicated that the platform was easy to understand and effective for learning basic PLC concepts and ladder logic programming. The use of low-cost hardware and open-source software increased engagement and confidence, as trainees were able to practice independently without licensing restrictions. Participants also appreciated the flexibility of OpenPLC for experimentation and system integration, which enhanced their understanding of real-world automation scenarios. Overall, the training improved practical skills and motivated trainees to further explore PLC-based control system development beyond maintenance-oriented applications.

This study demonstrates that OpenPLC is an effective open-source platform for overcoming the limitations of conventional PLC education and development, particularly high costs, proprietary software, and limited accessibility. By enabling PLC programming on low-cost and flexible hardware, OpenPLC supports hands-on learning, experimentation, and system development beyond traditional maintenance roles. Expanding OpenPLC adoption to non-maintenance staff, such as operators, engineers, and technical trainees, can enhance preventive maintenance activities by improving system understanding, early fault recognition, and data-driven control adjustments. This cross-functional capability promotes proactive maintenance practices, strengthens collaboration between departments, and contributes to improved system reliability and operational efficiency in modern industrial environments.

THANK-YOU NOTE

The author would like to express sincere gratitude to Akademi Komunitas Toyota Indonesia for providing the opportunity to conduct this community service program and support the development of this paper. Special thanks are also extended to the maintenance staff, former students of the academy, for their valuable technical assistance and guidance throughout the implementation of the program. Their contributions were essential to the successful completion of this work.

CONCLUSION

This study demonstrates that OpenPLC is an effective open-source platform for overcoming the limitations of conventional PLC education and development, particularly high costs, proprietary software, and limited accessibility. By enabling PLC programming on low-cost and flexible hardware, OpenPLC supports hands-on learning, experimentation, and system development beyond traditional maintenance roles. Expanding OpenPLC adoption to non-maintenance staff, such as operators, engineers, and technical trainees, can enhance preventive maintenance activities by improving system understanding, early fault recognition, and data-driven control adjustments. This cross-functional capability promotes proactive maintenance practices, strengthens collaboration between departments, and contributes to improved system reliability and operational efficiency in modern industrial environments.

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