

# Arduino Training for High School Students: Improving Technology Literacy and Creativity in the Digital Age

 Bodi Gunawan<sup>1\*</sup>,  Dedy Hamdani<sup>2</sup>,  Iwan Setiawan<sup>3</sup>,  Haditya Aprita Lora<sup>4</sup>

<sup>1,2,3,4</sup>University of Bengkulu  
Indonesia

✉ Corresponding Email: [bodi.gunawan@unib.ac.id](mailto:bodi.gunawan@unib.ac.id)\*



## Article Information:

Received September 15, 2025

Revised September 29, 2025

Accepted September 30, 2025

## Keywords:

Arduino; Education; Literacy of Technology; Microcontroller; STEM

## Abstract

**Background of study:** This community service activity aimed to address the gap in technological literacy and practical skills among students at SMAN 6 Bengkulu Tengah, Indonesia, by introducing the Arduino microcontroller platform as a tool for enhancing STEM education.

**Aims and scope of paper:** The primary objective was to assess the effectiveness of project-based Arduino training in improving students' understanding of electronics and programming. The study specifically evaluated cognitive gains, development of practical skills, and increased student confidence.

**Methods:** The program employed a participatory approach, combining interactive lectures, hands-on project development, and pretest and posttest evaluations using the Kahoot! platform. The training involved 41 participants and included collaborative project work in groups.

**Result:** The intervention resulted in a significant 36% increase in posttest scores (from 42% to 78%), with notable improvements in component knowledge (+82%) and schematic understanding (+79%). Additionally, 87% of participants reported increased confidence in experimenting with electronics projects.

**Conclusion:** Findings demonstrate that Arduino-based training effectively enhances technological literacy and STEM skills among high school students. The study recommends integrating microcontroller platforms into physics curricula and fostering school-university partnerships for sustainable implementation through teacher training, equipment provision, and module development aligned with the Merdeka Curriculum.

## A. Introduction

Technological developments, including the Internet of Things (IoT), robotics, and automation, have profoundly transformed the world, creating both opportunities and challenges across various domains (Xu et al., 2018). In the current epoch, characterized by the Fourth Industrial Revolution, a fundamental understanding of technology has evolved from being a mere asset to a crucial prerequisite for the younger generation. It is imperative that high school students, as future leaders, be equipped with technological skills from an early age so that they can adapt to the increasingly digital demands of the workforce (OECD, 2019). The introduction of affordable, user-friendly, and practical platforms such as Arduino constitutes a

How to Cite : Gunawan, B., Hamdani, D., Setiawan, I., & Lora, H.A. (2025). Arduino Training for High School Students: Improving Technology Literacy. *Aktual: Jurnal Pengabdian Kepada Masyarakat*, 3 (3), 141-148  
<https://doi.org/10.58723/aktual.v3i3.476>

ISSN : 2987-6052

Published by : CV Media Inti Teknologi

---

strategic initiative aimed at cultivating interest, programming logic, and creativity in the development of technology-based solutions.

Arduino is an ideal platform for introducing technology, especially for novices such as high school students, because it meets three main criteria: ease of use, affordability, and applicability (Banzi & Shiloh, 2022). Arduino is an open-source electronics platform that features a programming interface based on the C language (Arduino IDE) and a vibrant global community of users and support (Galadima, 2014). These characteristics facilitate the comprehension of fundamental electronics and coding principles for students, thereby eliminating the need to navigate complexities. Secondly, from a financial perspective, Arduino modules are relatively cost-effective, and their supporting components are readily available, making them a suitable option for educational activities in schools (Darmawan et al., 2017). Thirdly, Arduino's adaptability ensures its applicability to a diverse array of projects, ranging from rudimentary to intricate endeavors (Hadiyanto, 2021; Utari et al., 2025; Purba et al., 2025). These projects may include the control of light-emitting diodes (LEDs) or the development of fundamental automation and the Internet of Things (IoT) systems (Manfaluthy & Wilyanti, 2019; Kamaruddin et al., 2019). This capacity enables students to observe manifest outcomes of their educational endeavors, thereby reinforcing the efficacy of their learning experience. Furthermore, the open-source nature of Arduino facilitates boundless exploration, thereby encouraging students to engage in experimentation and innovation according to their individual interests (Çoban & Erol, 2022). The Arduino platform offers a multifaceted learning environment, characterized by its ease of use, cost-effectiveness, and extensive application potential. Beyond its role as an educational instrument, it functions as a gateway for students to cultivate STEM (Science, Technology, Engineering, and Mathematics) competencies that are highly sought after in the digital era (Kumar, 2022).

Within the Merdeka Curriculum, particularly in the domain of high school physics, a foundational discourse on electrical phenomena is embedded (Ulfa et al., 2024). This discourse encompasses the conceptual frameworks of electrical circuits, resistance, and rudimentary electronic components. This alignment suggests a congruence between the Arduino training curriculum, which is grounded in electrical principles and programming, and the curriculum's overarching objective of imparting contextual scientific understanding to students (Insani & Munandar, 2023). Arduino can serve as an ideal supplementary tool to visualize these theories, for example through simple projects like measuring voltage using a sensor or creating an interactive series-parallel circuit (Cabaccan et al., 2018). However, while the curriculum encompasses the fundamentals of electricity, its application frequently remains constrained to theoretical frameworks and conventional experiments, excluding the exploration of advanced technologies such as embedded systems or electronic programming. Nevertheless, the cultivation of such competencies is paramount in order to adequately prepare students for the digital age. Arduino, with its capacity to integrate electronics and coding, presents a solution to address this gap (Oteri, 2020). This training program was designed to provide students with a comprehensive understanding of the theoretical concepts. It also equips them with the practical skills necessary to apply these concepts in real-world projects. This approach stands in contrast to the more traditional classroom learning methods, which often focus on the transmission of knowledge without providing opportunities for hands-on experience (Becerra-Posada et al., 2022). Consequently, this initiative serves to enhance the existing curriculum, addressing the necessity for more applied and relevant STEM education that is aligned with technological advancements.

Despite Arduino's emergence as a global standard in STEM education, high school students in Indonesia continue to have minimal exposure to this platform (Ananingtyas et al., 2022). A limited survey of five schools in Bengkulu City revealed that only one school had an Arduino kit in its laboratory. In these institutions, the utilization of Arduino is frequently constrained to extracurricular pursuits or competitive events, rather than being incorporated into the institution's primary academic program. The introduction of Arduino to high school students is a significant enhancement to the educational curriculum, as previously discussed.

## B. Methods

The training program incorporated a blend of interactive lectures and hands-on, project-based exercises, as illustrated in Figure 1. Prior to implementation, a needs analysis was conducted through observation and discussion with the school. The analysis aimed to assess students' technological literacy, particularly in electronics, and to evaluate the availability of supporting facilities (Gunawan et al., 2024). The subjects of this community service activity were 41 students from Grade X at SMA Negeri 6 Bengkulu Tengah. The selection of these participants was based on preliminary findings indicating that although 58.8 percent of students expressed a strong interest in electricity and programming, the majority had never conducted practical experiments with electronic components, were unfamiliar with microcontrollers, and had no experience writing programming code. Furthermore, school teachers confirmed that Arduino-related content had not been integrated into either the Physics or Information and Communication Technology curricula, despite the availability of adequate laboratory infrastructure. Therefore, the entire class was included as participants without exclusion criteria to reflect the actual learning conditions at the partner school.

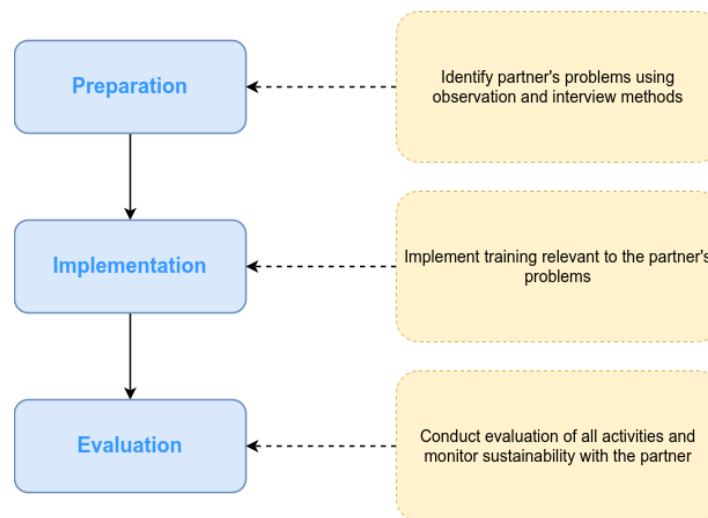


Figure 1. Overview of the IPTEKS Training Flow

The training materials were specifically designed to address these identified gaps, with a strong emphasis on introducing Arduino as an accessible entry point into electronics and programming. The instructional approach followed principles of project-based learning supported by scaffolding strategies (Alkhatib, 2018). The training process consisted of two main sessions. The first session involved an interactive lecture during which participants were introduced to the Arduino IDE environment and fundamental electronic components such as resistors, LEDs, sensors, and breadboards. The second session focused on collaborative project development, where students worked in small groups of approximately eight to ten students to construct an automatic distance measurement system using ultrasonic sensors, which was subsequently refined into a functional “digital ruler.” Throughout the activity, facilitators provided structured guidance, including sample code templates and real-time troubleshooting support, to help students navigate technical challenges.

## C. Results and Discussion

The community service activity began with an assessment of the needs of the partner, in this case SMAN 6 Bengkulu Tengah. The data presented herein were obtained through the implementation of in-person interviews with teaching professionals and the administration of the institution. The subjects of these interviews included the condition of the students, the infrastructure of the school, and the needs of the teaching professionals. A comprehensive list of these subjects can be found in Table 1.

Preliminary observations of students and teachers at the partner schools yielded several key findings regarding the level of readiness for Arduino training. A survey of the student body revealed that 58.8% of respondents expressed a high level of interest in electrical engineering and programming, indicating a positive potential for acceptance of technology-based training. However, the majority of students conceded that they had never engaged in electrical experiments involving electronic components and were unacquainted with the principles of microcontrollers or Arduino, despite the school having adequate laboratory facilities. In contrast, educators corroborated the absence of Arduino content within the curriculum, both in the Physics and Information and Communication Technology (ICT) disciplines. These findings highlight a gap between students' interests and their practical exposure to current technology, while also emphasizing the urgency of Arduino training as an effort to enrich students' learning experiences in STEM (Science, Technology, Engineering, and Mathematics). Therefore, the objective of this training is twofold: first, to introduce participants to the Arduino technology, and second, to serve as a catalyst in building practical and relevant technological literacy in line with the development of the digital era.

**Table 1.** School Needs Interview Question Indicators

Questions	Rating Scale
<b>A. Student Needs</b>	
1. Student interest in electrical phenomena and programming	Likert scale
2. Have students ever conducted practical experiments related to electricity?	Yes/No
3. Have teachers incorporated microcontroller and programming material into the school curriculum?	Yes/No
4. Have they ever participated in or conducted similar training before?	Yes/No
<b>B. Resource and infrastructure support</b>	
1. Does the school have a laboratory that supports electronics practical work?	Yes/No
2. Does the school have a computer laboratory?	Yes/No
<b>C. Teacher Needs</b>	
1. Have teachers ever used Arduino in their teaching?	Yes/No
2. What kind of training format would be most suitable for students at this school?	Yes/No
3. Is the school open to ongoing collaboration with our university in the development of STEM materials such as these?	Yes/No

Preliminary observations served as the foundation for the development of a training model, the objective of which is to familiarize students with Arduino devices. Arduino is an open-source microcontroller-based platform designed to facilitate the development of electronics projects and programming. In the context of physics education in secondary school, the Arduino platform holds significant pertinence due to its capacity to transform abstract electrical concepts, including electrical circuits, resistance, and sensors, into interactive real-world projects. For instance, students can verify Ohm's Law directly by measuring voltage and current using Arduino, or study physical phenomena such as the photoelectric effect through light sensors (LDR).

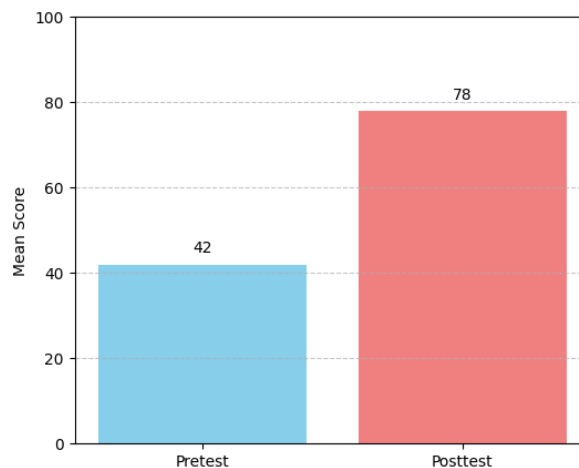
The applications of Arduino in technology are extensive, encompassing domains such as robotics, the Internet of Things (IoT), industrial automation, and renewable energy. For instance, Arduino-based temperature and humidity monitoring systems find application in precision agriculture, while introductory projects such as smart homes introduce students to the concept of automatic control. In the context of the Fourth Industrial Revolution, mastery of the Arduino programming language and associated skills, including problem-solving and interdisciplinary collaboration, is a critical component of STEM education (Lockridge et al., 2016) (Kim et al., 2020). Consequently, Arduino functions not only as a learning

instrument but also as a gateway for students to explore careers in engineering, computer science, or applied sciences.



**Figure 2.** Presentation on the use and application of Arduino

The Arduino training program was conducted on June 17, 2025, at SMA Negeri 6 Bengkulu Tengah with 41 participants. The training activity was conducted in the auditorium of SMA Negeri 6 Bengkulu Tengah. The event commenced precisely at 9:00 AM local time, inaugurated with a welcome address by the principal of SMA Negeri 6 Bengkulu Tengah, followed by a second address delivered by the Head of the Physics Education S1 Program, who is also a member of the community service team. The training session commenced with a pretest, employing the Kahoot! platform to evaluate the participants' preliminary comprehension of fundamental electronics and programming principles. The study incorporated 15 meticulously crafted multiple-choice questions, which participants answered in real time using mobile devices. A proprietary scoring system evaluated the accuracy and the speed of the responses. The preliminary results indicated that 63.4% of the participants lacked familiarity with fundamental electronic components, including resistors and sensors. Moreover, it was observed that all of the participants had no prior experience in writing programming code. This data was then used by the facilitators to adjust the pace and depth of the training material.

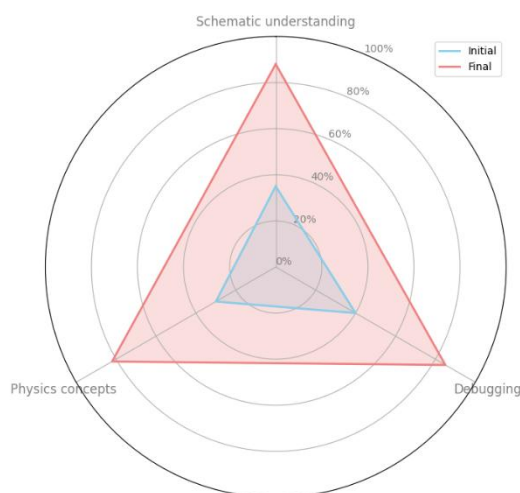


**Figure 3.** Pretest and posttest performance

The subsequent session entailed a presentation on the fundamental principles of electronics and programming, spanning a duration of one hour. During this presentation, the participants were acquainted with the primary components of the Arduino system, including the Uno board, the breadboard, resistors, and sensors, along with their respective functions as shown in Figure 2. The facilitator employed interactive demonstrations to illustrate the process of constructing a rudimentary circuit (i.e., an LED blink) while elucidating the electrical principles inherent in the high school physics curriculum. These principles encompassed such concepts as Ohm's Law and the notion of series-parallel circuits. Participants were then

guided through a series of exercises designed to reinforce fundamental programming concepts using the Arduino IDE. These exercises were meticulously structured to ensure a systematic and methodical approach, with each step carefully outlined in a dedicated module to ensure a seamless learning experience.

In the subsequent session, the training centered on the development of problem-based thematic projects. Participants were divided into groups of eight to ten individuals, tasked with developing rudimentary projects utilizing Arduino, such as a distance detection system that was subsequently upgraded into a digital ruler. The facilitator employed a scaffolding approach, providing fundamental code examples that could be adapted and subsequently leading the participants through debugging sessions when they encountered technical errors. The objective of this activity was twofold: first, to provide an opportunity for the application of the electrical theory learned in class; and second, to develop problem-solving skills.



**Figure 4.** Skill component comparison (initial vs. final)

At the conclusion of the training program, a posttest was administered using the Kahoot! platform. This posttest was designed to be equivalent in difficulty to the pretest, but it contained a different set of questions to assess changes in competency levels. A comparative analysis revealed a significant improvement, with the mean pretest score of  $42 \pm 11\%$  increasing to  $78 \pm 9\%$  on the posttest as shown in Figure 3. Participants who initially exhibited difficulty distinguishing between input and output pins (only 35% correct on the pretest) demonstrated 88% mastery on the posttest. Beyond the cognitive aspects, the Kahoot! questionnaire also revealed that 87% of the participants reported an increase in confidence in their ability to experiment with simple electronics projects following the training. The detailed pretest-posttest results are visualized in a radar chart in Figure 4, which shows improvements in all aspects, including component knowledge (+82%), schematic understanding (+79%), debugging skills (+76%), and application of physics concepts (+68%).

#### D. Conclusion

The Arduino introductory training at SMAN 6 Bengkulu Tengah effectively enhanced students' technological literacy and STEM skills, demonstrated by a 36% increase in posttest scores, with notable gains in component knowledge and schematic understanding, as well as a marked rise in student confidence, reported by 87% of participants. To sustain and expand this impact, it is recommended that Arduino-based learning be formally integrated into the high school physics curriculum under the Merdeka Curriculum, particularly in electricity-related topics, supported by structured teacher training, development of localized instructional modules, and strengthened school-university partnerships. As a concrete follow-up, the community service team will develop a curriculum-aligned Arduino learning package, conduct a teacher capacity-building session at the partner school, and facilitate the establishment of a student STEM club to encourage continuous, project-based exploration beyond the classroom, thereby fostering a sustainable ecosystem for digital literacy and innovation in line with the demands of the Fourth Industrial Revolution.

### E. Acknowledgment

We express our profound appreciation to the Principal of SMAN 6 Bengkulu Tengah, for authorizing and facilitating the implementation of this training. We offer our gratitude to all the teachers for their steadfast dedication and active involvement in the training, and to the students for their enthusiastic participation during implementation in class.

### References

- Alkhatib, O. J. (2018). An interactive and blended learning model for engineering education. *Journal of Computers in Education*, 5(1), 19–48. <https://doi.org/10.1007/s40692-018-0097-x>
- Ananingtyas, R. S. A., Sakti, R. E., Hakim, M. H., & Putra, F. N. (2022). Pengembangan media pembelajaran berbasis arduino pada pembelajaran stem dalam meningkatkan literasi sains dan digital. *Briliant: Jurnal Riset Dan Konseptual*, 7(1), 178. <https://doi.org/10.28926/briliant.v7i1.795>
- Banzi, M., & Shiloh, M. (2022). *Getting Started with Arduino (4th ed.)*. Maker Media.
- Becerra-Posada, T., García-Montes, P., Sagre-Barbosa, A., Carcamo-Espitia, M. I., & Herazo-Rivera, J. D. (2022). Project-based learning: The promotion of communicative competence and self-confidence at a state high school in colombia. *HOW*, 29(2), 13–31. <https://doi.org/10.19183/how.29.2.560>
- Cabaccan, C. N., Reidj, F., & Cruz, G. (2018). Power characterization of raspberry pi agricultural sensor nodes using arduino based voltmeter. *2018 3rd International Conference on Computer and Communication Systems (ICCCS)*, 349–352. <https://doi.org/10.1109/CCOMS.2018.8463240>
- Çoban, A., & Erol, M. (2022). STEM Education of Kinematics and Dynamics Using Arduino. *The Physics Teacher*, 60(4), 289–291. <https://doi.org/10.1119/10.0009994>
- Darmawan, A., Ratnadewi, R., Sartika, E. M., Br. Pasaribu, N. T., & Arlando, R. (2017). Basic arduino programming training for high school students. *THE SPIRIT OF SOCIETY JOURNAL*, 1(1). <https://doi.org/10.29138/scj.v1i1.456>
- Galadima, A. A. (2014). Arduino as a learning tool. *2014 11th International Conference on Electronics, Computer and Computation (ICECCO)*, 1–4. <https://doi.org/10.1109/ICECCO.2014.6997577>
- Gunawan, B., Putri, D. H., Risdianto, E., Ahda, N. V., Aqil, M. A., & Karuniawan, A. (2024). Pelatihan google workspace for education dalam menunjang kegiatan belajar-mengajar. *MIMBAR INTEGRITAS : Jurnal Pengabdian*, 4(1), 65. <https://doi.org/10.36841/mimbarintegritas.v4i1.5580>
- Hadiyanto, G. (2021). P pemanfaatan arduino uno sebagai alat ukur offset voltage pada infra red detector type to39 dengan pembanding alat ukur dmm. *Elkom : Jurnal Elektronika Dan Komputer*, 14(1), 121–129. <https://doi.org/10.51903/elkom.v14i1.331>
- Insani, A. H., & Munandar, K. (2023). Studi literatur: Pentingnya pembelajaran berdiferensiasi di era kurikulum merdeka untuk meningkatkan hasil belajar peserta didik. *ScienceEdu*, 6(1), 6. <https://doi.org/10.19184/se.v6i1.39645>
- Kamaruddin, F., Nik Abd Malik, N. N., Murad, N. A., Abdul Latiff, N. M., Yusof, S. K. S., & Hamzah, S. A. (2019). IoT-based intelligent irrigation management and monitoring system using arduino. *TELKOMNIKA (Telecommunication Computing Electronics and Control)*, 17(5), 2378. <https://doi.org/10.12928/telkomnika.v17i5.12818>
- Kim, S.-M., Choi, Y., & Suh, J. (2020). Applications of the open-source hardware arduino platform in the mining industry: A review. *Applied Sciences*, 10(14), 5018. <https://doi.org/10.3390/app10145018>
- Kumar, E. S. (2022). Arduino working principle and it's use in education. *International Journal for Research in Applied Science and Engineering Technology*, 10(4), 2314–2319. <https://doi.org/10.22214/ijraset.2022.41784>
- Lockridge, G., Dzwonkowski, B., Nelson, R., & Powers, S. (2016). Development of a low-cost arduino-based sonde for coastal applications. *Sensors*, 16(4), 528. <https://doi.org/10.3390/s16040528>
- Manfaluthy, M., & Wilyanti, S. (2019). Pemanfaatan fasilitas it untuk jaringan pencahayaan led di smartroom. *Jurnal Rekayasa ElektriKa*, 15(2). <https://doi.org/10.17529/jre.v15i2.13032>

- 
- OECD (2019), *Trends Shaping Education 2019*, OECD Publishing, Paris, [https://doi.org/10.1787/trends\\_edu-2019-en](https://doi.org/10.1787/trends_edu-2019-en)
- Oteri, O. M. (2020). The arduino e-kit as applied in engineering, science and technology e-learning. *2020 Sixth International Conference on E-Learning (Econf)*, 285–289. <https://doi.org/10.1109/econf51404.2020.9385459>
- Purba, M., Hamdani, D., & Gunawan, B. (2025). Development of props for monitoring temperature, air pressure, and wind speed to improve science process skills of high school students. *Asian Journal of Science Education*, 7(1), 84–96. <https://doi.org/10.24815/ajse.v7i1.42484>
- Ulfa, S., Irvani, A. I., & Warliani, R. (2024). Pengembangan modul ajar fisika kurikulum merdeka. *Jurnal Pendidikan Fisika Dan Sains (JPFS)*, 7(1), 51–59. <https://doi.org/10.52188/jpfs.v7i1.562>
- Utari, N., Hamdani, D., & Gunawan, B. (2025). Biot-savart props based on arduino uno for measuring magnetic fields on wire and solenoids. *Asian Journal of Science Education*, 7(1), 97–114. <https://doi.org/10.24815/ajse.v7i1.43992>
- Xu, M., David, J. M., & Kim, S. H. (2018). The fourth industrial revolution: Opportunities and challenges. *International Journal of Financial Research*, 9(2), 90. <https://doi.org/10.5430/ijfr.v9n2p90>

---

**Copyright Holder**

© Gunawan, B., Hamdani, D., Setiawan, I., & Lora, H.A.

**First publication right:**

Jurnal Pengabdian Kepada Masyarakat

This article is licensed under:

