

## 4 Degree of Freedom Arm Robotics Training for State Vocational High School 1 Depok

Mauludi Manfaluthy<sup>1</sup>, Brainvendra Widi Dionova<sup>2</sup>, Revita Desi Hertin<sup>3</sup>

<sup>1,2,3</sup>Universitas Global Jakarta

\* e-mail: [mauludi@jgu.ac.id](mailto:mauludi@jgu.ac.id)

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### Abstract

This activity provided an in-depth exploration of both the foundational principles and the latest advancements in robotics, with a particular emphasis on industrial robots. It was designed to equip students with essential skills needed for assembling and operating robotic systems. A key component of the program was the 4 Degree of Freedom (DOF) Arm Robot, a sophisticated system that integrated mechanical and electronic elements—commonly referred to as mechatronics. This robot was capable of performing various tasks through its four primary degrees of freedom: forward-backward, left-right, and up-down movements, along with three additional wrist movements—yaw, pitch, and roll. During the training, students engaged in hands-on activities, using joystick controls to manipulate the robot's arm for moving objects. This practical exercise demonstrated how robotics could enhance efficiency in tasks involving object handling, thereby reducing the physical strain on human workers. To ensure a comprehensive understanding of robotics, it was crucial to have instructors who were not only knowledgeable but also experienced in electrical engineering, particularly in robotics. These educators provided essential guidance and support, helping students grasp complex concepts and apply them effectively. The effectiveness of the training program was demonstrated by the significant improvement in students' knowledge, as reflected in pre- and post-training assessments. Additionally, students successfully assembled robots using the provided materials and components, showcasing their newly acquired practical skills. Overall, this activity fostered both theoretical understanding and hands-on proficiency, preparing students for future challenges in the field of robotics.

**Keywords:** Arm robot; Robotic; Arduino; Mechatronic

### Abstrak

Kegiatan ini menawarkan eksplorasi mendalam mengenai prinsip dasar serta kemajuan terkini dalam bidang robotika, dengan fokus khusus pada robot industri. Program ini dirancang untuk membekali siswa dengan keterampilan praktis dalam merakit dan mengoperasikan sistem robotik, yang sangat relevan di era teknologi saat ini. Fitur utama dari program ini adalah Robot Lengan 4 Degree of Freedom (DOF), sebuah sistem canggih yang menggabungkan komponen mekanik dan elektronik—sering disebut mekatronika. Robot ini dirancang untuk melakukan berbagai tugas fisik dengan empat derajat kebebasan utama: gerakan maju-mundur, kiri-kanan, dan atas-bawah, serta tiga gerakan tambahan pada pergelangan tangan yaitu yaw, pitch, dan roll. Selama pelatihan, siswa terlibat dalam kegiatan praktis yang memungkinkan mereka menggunakan kontrol joystick untuk memanipulasi lengan robot dalam memindahkan benda. Latihan praktis ini bertujuan untuk memperlihatkan bagaimana teknologi robotika dapat menyederhanakan dan

meningkatkan efisiensi dalam tugas-tugas yang melibatkan penanganan objek, serta mengurangi beban fisik pada pekerja manusia. Untuk memastikan siswa mendapatkan pemahaman yang mendalam tentang robotika, sangat penting memiliki pengajar yang tidak hanya berpengetahuan luas tetapi juga berpengalaman di bidang teknik elektro, khususnya robotika. Para pendidik ini memberikan bimbingan yang sangat dibutuhkan, membantu siswa memahami dan menerapkan konsep-konsep kompleks secara efektif. Keefektifan program pelatihan ini tercermin dari peningkatan signifikan dalam pengetahuan siswa, yang terlihat dari hasil penilaian sebelum dan sesudah pelatihan. Selain itu, siswa berhasil merakit robot menggunakan bahan dan komponen yang disediakan, menyoroti keterampilan praktis baru mereka. Secara keseluruhan, kegiatan ini tidak hanya memperdalam pemahaman teoretis tetapi juga membekali siswa dengan keterampilan praktis yang siap menghadapi tantangan di masa depan dalam bidang robotika.

**Kata kunci:** Lengan robot; robotika; Arduino; mekatronika

## INTRODUCTION

Every student in the globalization era is expected to possess critical thinking skills, a broad perspective, and creative ability in order to be able to quickly adapt to changing circumstances. As a result, the development of one's thought processes and conduct is just as important as the development of scientific and theoretical thinking skills at every level of education. Vocational high schools offer structured courses that are specifically designed to help students get ready for working life. According to Article 15 of Law No. 20 of 2003 regulating the National Education System, vocational education is secondary education that primarily prepares students for employment in particular professions. As a result, Vocational High Schools' (SMK) primary objective is to get pupils ready for the workforce. Students who graduate from vocational schools are expected to become graduates who are ready to work.

Vocational schools, one of the key players in workforce preparation, must constantly be prepared to meet the increasing demands of the market in the increasingly competitive and actual industry. Based on practical experience, it is currently believed that vocational schools do not adequately prepare their graduates to enter the workforce (Wibowo, 2016). Perhaps this is due to different goals between the educational and corporate sectors; the former values quick graduation rates, the latter values graduates with strong technical skills and moral character.

Most of Indonesia's jobless population, according to the Central Statistics Agency (BPS) (2022), are graduates of vocational high schools (SMKs). In February 2022, the percentage of unemployed people having a final vocational school degree was 22.33%. The majority of graduates from vocational schools wish to start working right immediately but are not interested in entering the corporate sphere. This results from a gap between the number of graduates from vocational schools and available jobs.

This robotics program was also selected since it is appropriate for all students learning styles. Three categories—auditory, visual, and kinesthetic—can be used to categorize an individual's learning preferences. When studying content directly, it will be easier for someone who learns best visually to absorb it. Participants may instantly observe every element of the robot's components when learning about them. When a teacher explains something and there is student discussion, it will be simpler for someone with an auditory learning style to understand.

Students with an auditory learning style will be helped from this Robotics course since the trainer will explain the introduction content at the start of the training, and students will be able to debate it with one another throughout the training. Students with a kinesthetic learning style will better

understand something if they do it immediately. This Robotics training is definitely ideal for people with a kinesthetic learning approach, as students may create their robots using the components provided.

The utilization of robots technology in education has a significant impact on students' problem-solving and creative skills. Robotics allows students to understand physics, mathematics, and logic principles through programming. Students can also learn how to operate electrical/electronic systems in robots. Students also comprehend the forces that drive robots to move. While assembling the robot, students learn about various geometric shapes. An experiment showed that introducing robotics technology to children improves their talents and interests in Science, Technology, Engineering, and Mathematics (Anshar, Muh, 2020).

This robotics technology course was conducted at SMKN 1 Depok. This vocational high school is located in Depok, West Java, Indonesia. It is specifically situated on Jalan K.H. Mas Mansyur No. 58, Depok, a strategic and easily accessible part of the city. Depok is recognized as an educational city in West Java, with numerous schools and educational institutions providing a variety of study programs and training. SMKN 1 Depok is one of these institutions, with a focus on developing technical and vocational skills to prepare students for job market by providing meaningful practical experience.

The goal of this service project, which involves students and the implementation team, is to give them a basic understanding of robotics and its technology in addition to helping them assemble robots. The word "robot" originates from the Czech word "robota," which denotes a worker or coolie who never tires. Robots are, to put it simply, electro-mechanical devices with the ability to respond to their surroundings and operate independently to accomplish specific tasks (Anshar 2020). In contrast, a robot is defined as something that can be programmed and reprogrammed, has a mechanical manipulator (drive), is intended to move objects, has a variety of flexible programmes, and can be converted to do a variety of jobs by the Robot Institute of America (1979) (Anshar 2020). The use of robotics technology is critical to human survival.

According to Teavuihuang (2020), robots serve various functions, including:

- 1) Industrial Applications: In the industrial sector, robots are employed in various processes, particularly in production. They enhance productivity, improve efficiency, and minimize human error
- 2) Dangerous Environments : Robots are utilized in hazardous environments where human safety might be compromised. They can enter dangerous areas or perform risky tasks, such as detecting nuclear waste or extinguishing fires.
- 3) Entertainment: Robots can also be designed for entertainment purposes. Examples include dancing robots, singing robots, and robots for competitions like robot soccer, which features annual contests
- 4) Service Roles : Robots can be programmed to provide various services, potentially replacing human functions with greater efficiency. In hospitals, for instance, robots can assist with patient care, deliver food, and perform basic examinations. During a pandemic, where reducing human interaction is crucial, robots play a vital role in handling patient care and performing essential tasks.
- 5) Household Assistance : Robots can also be programmed to assist with household chores, such as maintaining cleanliness and ensuring security. As IoT (Internet of Things) technology advances, robots' capabilities continue to improve.

As IoT (Internet of Things) technology continues to develop, the capabilities of robots are also getting higher. There are various kinds of robots, including (1) robots that can move (Mobile Robot) and robots that cannot move/stay in place (Non - Mobile Robot), (2) Legged robots and Wheeled Robots, (3) Robots for competition needs and entertainment such as: Robot Soccer, Robot Fire Extinguisher, Search and Rescue Robots, Dancing Robots. A simple robot has at least 3 (three) elements, namely: robot brain, actuator and sensors. The robot's brain is usually a microcontroller, sensors function to sense environmental conditions and drive to run the robot. The microcontroller that is popularly used is Arduino, because it is open source, there are many libraries available that support program implementation.

## METHODE

In response to the issues raised above, this service activity provided Robotics technology instruction for students on a student scale, with presenters from the Implementation Team. Robots and instructional materials were created during the preparatory phase to meet the needs and conditions of the SMKN 1 Depok environment. Administrative duties for organizing committees, presenter training, and participant registration were also included in the preparations. Pre- and post-tests were given to the participants in order to evaluate the effectiveness of the instruction.

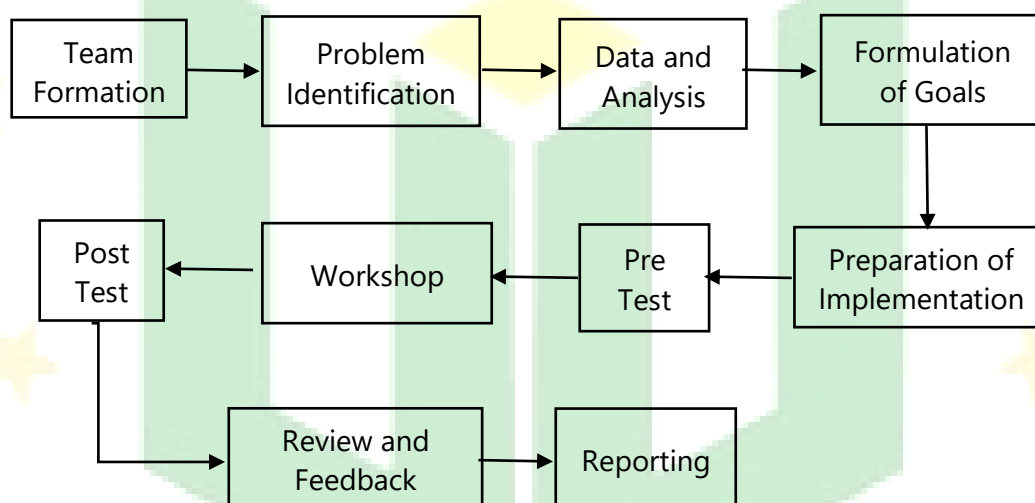


Figure 1. Retention of Robotic Community Service Training Activities

The implementation of community service projects was divided into three primary stages: planning, carrying out, and reviewing the activities. The team was formed in April 2023, and the operations came to an end in September 2023 when the report was prepared. Thirty-seven male and female students from SMKN 1 Depok, class XI of the Software and Game Development Program, participated in the training. On Tuesday, August 1, 2023, the training took place on the second floor of the SMKN 1 Depok building from 8:00 to 13:00 WIB.

## RESULTS AND DISCUSSION

Thirty-seven students from SMKN 1 Depok attended and participated in the community service activities. Participants were split up into multiple groups, and each group got a chance to see the robot arm, which a group of student tutors explained and showed. An introduction to robots and an overview of modern technological developments preceded the



start of the program. Before that, a test was given to determine the participants' basic level of comprehension of robots.

After the introductory material, participants proceeded to hands-on assembly of the robot arm using the materials, components, and tools provided. During this activity, the participants showed enthusiasm and engagement. At the end of the session, students were administered a post-test with the same questions as the pre-test. A comparison of the test results for the students who participated in the activity is shown in the figure below

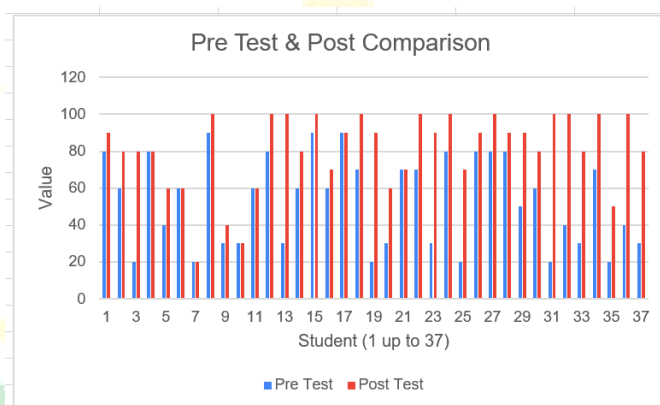


Figure 2. Comparison of student test results before and after giving the material

This image indicates that, before to engaging in the exercise, students knowledge and comprehension were still weak (the class average was 53.2%). Following their participation in the program, 80.5% of the students had more knowledge. In general, the information presented throughout the course was understood by students.



Figure 3 is the last session of the activity, students are invited to take a photo together as a memory to make the activity even more memorable

## CONCLUSIONS AND SUGGESTIONS

The students' level of knowledge and understanding increased through the enthusiasm built during their participation in the activities. The post-test results showed a significant improvement in the participants' knowledge. It was hoped that more students would develop an

interest in learning and mastering robotics and that robotics extracurricular activities will be established at SMKN 1 Depok. The next plan involved advancing to the exploration stage of robotics programming, where participants will be taught to program robots using the image/visual-based Scratch programming language.

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