



From Sensors to Robots: Learning Instrumentation Physics Technology and Computer Vision for Students of SMA IT Daarul 'Ilmi Bandar Lampung

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ABSTRACT

This community service activity was motivated by students' limited understanding of instrumentation physics and the lack of exposure to the application of technologies such as sensors, microcontrollers, and computer vision in both daily life and industry, including related study prospects. This activity aims to enhance students' understanding and interest in instrumentation physics through socialization and technology-based demonstrations. The implementation methods included pre-tests and post-tests to measure improvements in students' understanding, material delivery sessions, and demonstrations of various technologies, such as sensor-based water quality monitoring systems, microcontroller-based automatic door systems, a 4-DOF robotic arm, and a Python-based computer vision system for hand detection. The results showed an improvement in students' understanding, as indicated by an increase in the average pre-test score ($\bar{x} = 2.63$) to the post-test score ($\bar{x} = 3.31$), with a mean gain of ($\Delta\bar{x} = 0.68$). In addition, students' interest in pursuing further studies in instrumentation physics also increased after the activity. Overall, this activity proved to be effective in providing students with interactive, contextual, and application-oriented learning experiences.

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A. INTRODUCTION

The advancement of science and technology in the era of the Industrial Revolution 4.0 demonstrates the integration of physics, electronics, and artificial intelligence in various modern systems (Jagatheesaperumal et al., 2021). Instrumentation physics plays a crucial role in this process, as it focuses on measurement techniques, signal processing, and sensor-based system control (Zangl, 2010). Sensors function to convert physical quantities into electrical signals that can be processed by digital systems, forming the foundation for the development of automation and robotics technologies (Soares et al., 2024). This development is further supported by advancements in computer vision, which enable computer systems to automatically understand, analyze, and interpret visual information from digital images



(Zribi et al., 2024). In recent years, robotics and computer vision technologies have been increasingly implemented not only in industry but also in STEM-based education to support interactive and technology-oriented learning environments. Several recent studies have highlighted the growing use of robotics and computer vision technologies in STEM education to improve students' practical, computational, and digital skills (Maharani, 2025; Siswoyo et al., 2025). These technologies also encourage students to better understand the relationship between theoretical concepts and their real-world applications through hands-on activities and project-based learning. However, the integration of instrumentation physics concepts, sensors, robotics, and computer vision in high school learning activities is still limited.

The utilization of technology in education has made a significant contribution to improving the quality of learning, particularly in science subjects (Erlina, 2024). The inherently abstract nature of physics concepts requires more contextual and application-based learning approaches. The use of sensor-based media and digital technology can help visualize these concepts, making them easier for students to understand (Wijaya et al., 2025). The integration of technologies such as computer vision in learning also has the potential to enhance students' digital literacy and critical thinking skills (Long, 2020).

Several previous studies have shown that technology-based learning can enhance students' conceptual understanding as well as their science process skills (Alshammary & Alhalafawy, 2023; Sailer et al., 2024; Yeung et al., 2021). The use of sensor-based devices in physics education has also been proven effective in increasing students' active engagement (Masrifa et al., 2025). Furthermore, the application of visual-based technologies such as computer vision can support more interactive and engaging learning experiences (Edy et al., 2025; Ginting & Messe, 2025). These findings indicate that the integration of technology in education is a relevant approach to addressing the challenges of learning in the digital era.

Learning activities that are still predominantly theoretical limit students' opportunities to gain direct experience in understanding modern technology. This condition leads to low student interest in Physics, particularly in the field of Instrumentation, as a choice for further study. Therefore, a socialization activity is needed to introduce the basic concepts of sensors, instrumentation systems, and the application of computer vision in an applied manner through demonstrations and simple practical activities. This activity also includes an introduction to the Instrumentation Physics study program at the university level as an alternative pathway for further education (Afandi, 2025; Effendy & Hamid, 2016).

B. METHODS

This community service activity was conducted in the form of socialization and an introduction to Instrumentation Physics and Computer Vision for students of SMAIT Daarul Ilmi Bandar Lampung. The activity aims to enhance students' understanding and interest in the application of instrumentation physics in daily life as well as modern technologies such as sensors, microcontrollers, and artificial intelligence. In addition, it provides an overview of real-world applications of instrumentation technology through demonstrations of research-based systems and introduces opportunities for further study in applied physics. The success indicators of this activity include increased students' understanding and interest in instrumentation physics and technology-based learning, as measured through pre-test and post-test questionnaires. The analysis method used in this study was descriptive quantitative analysis by comparing the average scores obtained from the pre-test and post-test results. The activity was carried out systematically through the following stages (Figure 1):

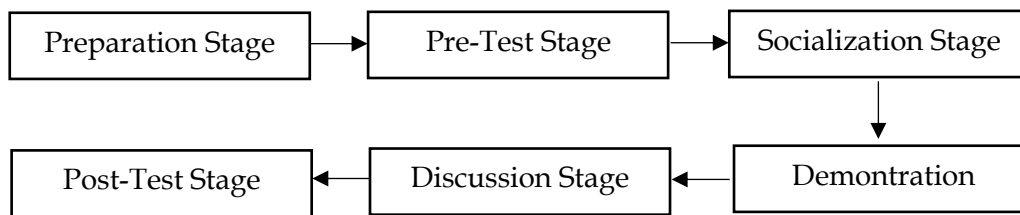


Figure 1. Community Service Activity Flow

1. Preparation Stage

The preparation stage was carried out through coordination with the partner school, the development of socialization materials on Instrumentation Physics and Computer Vision, and the preparation of demonstration tools, including a sensor-based water quality monitoring system, a microcontroller-based keypad system, a 4-DOF robotic arm, and a Python-based computer vision system.

2. Pre-Test Stage

The pre-test was conducted prior to the main activity, during which students completed a questionnaire to assess their initial knowledge of instrumentation physics, the function of sensors, microcontrollers, and their interest in the field. The questionnaire was designed using a Likert scale of 1–5, where a score of 1 indicates “no understanding” and a score of 5 indicates “very high understanding.” In addition to closed-ended questions, open-ended questions were included to explore students’ expectations after participating in the socialization as well as to gather suggestions for future improvements. This stage served as baseline data to determine students’ initial level of understanding and interest before the socialization materials were delivered.

3. Socialization Stage

The activity included an introduction to the Physics Study Program at the University of Lampung, an explanation of the fundamental concepts of Instrumentation Physics, and an overview of its applications in daily life and industry. In addition, various research outcomes in the field of physics were introduced, such as plant disease classification using leaf images, a sensor-based water quality monitoring system, a keypad and microcontroller-based door system, and a 4-DOF robotic arm.

4. Demonstration Stage

The activity was conducted by presenting several systems, including a video demonstration of a 4-DOF robotic arm, as well as a camera-based computer vision implementation using Python that utilizes right- and left-hand detection to perform simple operations in real time. This stage provided students with direct, interactive experience in the practical application of instrumentation technology.

5. Discussion Stage

The discussion session was conducted by providing students with the opportunity to ask questions and engage in discussions regarding the presented materials and demonstrated technologies. The discussion also covered the application of instrumentation in daily life as well as its potential for future development.

6. Post-Test Stage

The post-test was conducted to measure the improvement in students' understanding and interest after the socialization activity. Students completed a questionnaire using a Likert scale of 1-5, covering their understanding of basic instrumentation concepts, applications in daily life and industry, the function of microcontrollers, and their interest in pursuing further studies in instrumentation physics. In addition, open-ended questions were included to explore students' interests in future development areas and to gather suggestions for improving the activity. The post-test results were used to evaluate the effectiveness of the program.

C. RESULTS AND DISCUSSION

The community service activity conducted at SMAIT Daarul Ilmi Bandar Lampung involved 21 students as respondents in the pre-test and post-test stages. The activity included socialization of instrumentation physics, technology demonstrations, and an introduction to computer vision and robotics. A pre-test was conducted to assess students' initial understanding of instrumentation physics, sensors, and microcontrollers. The pre-test results indicated that students' initial understanding was in the moderate to low category, with an average score of ($\bar{x} = 2.63$) on a 1-5 Likert scale. Documentation of the activity is presented in Figure 2. This activity provided students with direct exposure to modern technology applications in instrumentation physics, robotics, and computer vision, thereby increasing their interest in technology-based learning and higher education in Instrumentation Physics. To support program sustainability, the activity is expected to become an initial collaboration between the university and the school through future technology workshops and practical learning activities.



Figure 2. Instrumentation Physics Socialization Activity at SMAIT Daarul Ilmi

Furthermore, the technology demonstration was conducted by presenting a Python-based computer vision implementation that utilizes right- and left-hand detection to perform simple operations. The documentation of this activity is presented in Figure 3.



Figure 3. Computer Vision Demonstration Based on Hand Detection Using Python

In addition, a demonstration of a 4-DOF robotic arm was presented as an example of a microcontroller-based control system. The demonstration video shows how the robot can move in a controlled manner based on the programmed system. The documentation of this activity is presented in Figure 4.



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Figure 4. Demonstration of a Microcontroller-Based 4-DOF Robotic Arm

The post-test results indicate an improvement in students' understanding after participating in the entire series of activities. Based on data analysis, the average post-test score was ($\bar{x} = 3.31$) on a Likert scale of 1-5. This value increased compared to the average pre-test score of ($\bar{x} = 2.63$), resulting in a mean improvement of ($\Delta\bar{x} = 0.68$) points.

The improvement is also supported by changes in the distribution of students' understanding levels (Figure 5). In the pre-test stage, the percentages of students in the "not understanding" and "poor understanding" categories were relatively high, at 25.7% and 20.0%, respectively. This indicates that prior to the activity, most students still had limited understanding of basic concepts in instrumentation physics. However, after the



implementation of the socialization and demonstration activities, these percentages decreased significantly to 4.8% and 13.1%, respectively. In contrast, higher levels of understanding showed an increase, where the “fair understanding” category rose to 42.9%, and the “good understanding” category increased from 11.4% to 25.0%

This improvement indicates a positive enhancement in students’ understanding of basic instrumentation concepts, their applications in daily life and industry, as well as their comprehension of the role of microcontrollers in instrumentation systems. In addition, students’ interest in pursuing further studies in instrumentation physics also increased, as reflected by the shift in response distribution toward higher levels of understanding in the post-test.

The comparison of pre-test and post-test results is presented in Figure 5, which shows a shift in the distribution of students’ levels of understanding toward higher categories after the socialization and demonstration activities were conducted.

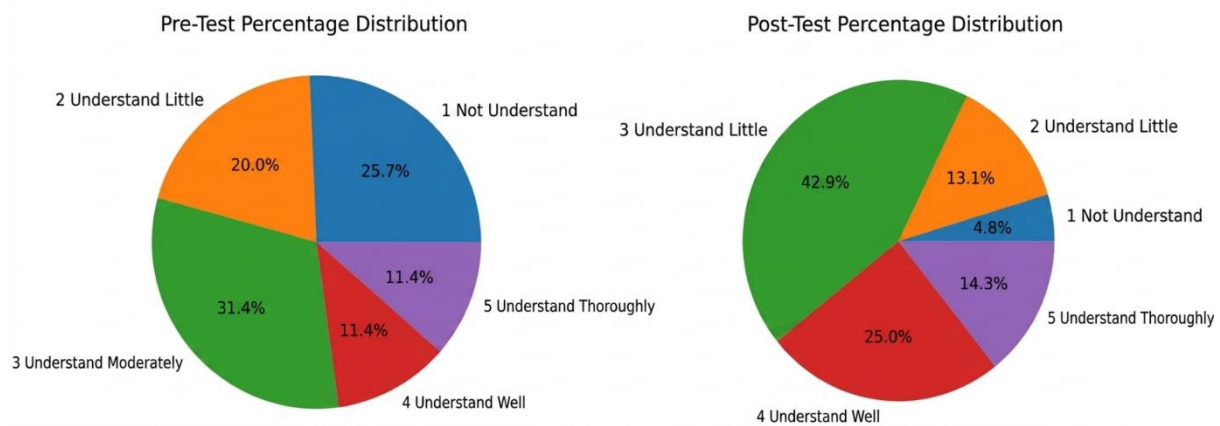


Figure 5. Comparison of Students’ Pre-Test and Post-Test Results

Overall, the results of the activity indicate that the socialization method combined with technology demonstrations, such as computer vision and robotics, was able to enhance students’ understanding and interest in the field of instrumentation physics. This approach proved to be effective in providing students with more interactive and contextual learning experiences.

D. CONCLUSION

This community service activity had a positive impact in improving students’ understanding and interest in instrumentation physics. This is evidenced by the results of the pre-test and post-test evaluations, where the average pre-test score was ($\bar{x} = 2.63$) and the post-test score increased to ($\bar{x} = 3.31$), resulting in an improvement of ($\Delta\bar{x} = 0.68$) points. This improvement is reflected in students’ understanding of basic instrumentation concepts, their ability to relate the application of sensors and microcontrollers in daily life, as well as their increased comprehension of the role of instrumentation physics in modern technology.

In general, the activities involving socialization, technology demonstrations, computer vision, and a 4-DOF robotic arm were effective in improving students’ understanding. However, time constraints limited the depth of material delivery, and therefore, it is



recommended to extend the duration and increase the proportion of practical sessions in future activities.

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F. AUTHOR CONTRIBUTIONS

All authors contributed to the implementation of the community service activity and the preparation of this article. The contributions of each author are as follows: design of the socialization activities and coordination with partners: Surya Prihanto (SP), Yusri Al Fath (YAF), Ayu Aprilia (AA), and Ahmad Faruq Abdurrahman (AFA); implementation of the socialization activities, technology demonstrations, and fieldwork: Surya Prihanto (SP), Yusri Al Fath (YAF), Ayu Aprilia (AA), Ahmad Faruq Abdurrahman (AFA), Raihan Rafii (RR), Dafa Ariwinadi (DA), Satrio (S), and Muhammad Ajie Wahyudi (MAW); collection of pre-test and post-test data: Surya Prihanto (SP), Yusri Al Fath (YAF), Ayu Aprilia (AA), Raihan Rafii (RR), Dafa Ariwinadi (DA), Satrio (S), and Muhammad Ajie Wahyudi (MAW); data processing and analysis: Surya Prihanto (SP), Yusri Al Fath (YAF), and Ahmad Faruq Abdurrahman (AFA); manuscript preparation: Surya Prihanto (SP), Yusri Al Fath (YAF), and Ayu Aprilia (AA); and manuscript revision and finalization: all authors (faculty members and students).

G. REFERENCES

- Afandi, H. A. (2025). Penerapan Pembelajaran dengan Metode *Problem Based Learning* (Pbl) Melalui Media Berbasis Android Integrasi Teknik Responsi Pretest Dan Postest. *Journal Creativity*, 3(1), 310-324. <https://doi.org/10.62288/9qx9pd23>
- Alshammary, F. M., & Alhalafawy, W. S. (2023). Digital Platforms and the Improvement of Learning Outcomes: Evidence Extracted from Meta-Analysis. *Sustainability*, 15(2), 1305. <https://doi.org/10.3390/su15021305>
- Edy, M. R., Zulfikar, M. I., Nurfauziah, Nirmala, P., & Agusnaya, N. (2025). Transformasi Pembelajaran Vokasi Pertanian melalui Integrasi IoT dan Computer Vision pada Smart Greenhouse di SMKN 4 Barru: Penelitian. *Jurnal Pengabdian Masyarakat Dan Riset Pendidikan*, 4(2), 11622-11630. <https://doi.org/10.31004/jerkin.v4i2.3765>
- Effendy, I., & Hamid, M. A. (2016). Pengaruh Pemberian Pre-Test dan Post-Test Terhadap Hasil Belajar Mata Diklat HDW.DEV.100.2.A pada Siswa SMK Negeri 2 Lubuk Basung. *VOLT: Jurnal Ilmiah Pendidikan Teknik Elektro*, 1(2), 81-88. <https://doi.org/10.30870/volt.v1i2.2873>
- Erlina, N. (2024). Potensi Teknologi Pembelajaran IPA di Indonesia melalui Pengetahuan Digital Ekspor dalam Menyiapkan Ekonomi Berkelanjutan Mahasiswa Program



- Pendidikan. *Wahana Matematika Dan Sains: Jurnal Matematika, Sains, Dan Pembelajarannya*, 18(2), 68-85. <https://doi.org/10.23887/wms.v18i2.88198>
- Ginting, R. F. A., & Messe, F. E. (2025). *Development Of An Educational Puzzle Game Using Computer Vision-Based Hand Tracking For Early Childhood*. *HOAQ (High Education of Organization Archive Quality): Jurnal Teknologi Informasi*, 16(1), 16-22. <https://doi.org/10.52972/hoaq.vol16no1.p16-22>
- Jagatheesaperumal, S. K., Rahouti, M., Ahmad, K., Al-Fuqaha, A., & Guizani, M. (2021). *The Duo of Artificial Intelligence and Big Data for Industry 4.0: Review of Applications, Techniques, Challenges, and Future Research Directions* (arXiv:2104.02425). arXiv. <https://doi.org/10.48550/arXiv.2104.02425>
- Long, L. (2020). Application of modern information technology in mathematical technology. *2020 International Conference on Artificial Intelligence and Computer Engineering (ICAICE)*, 463-471. <https://doi.org/10.1109/ICAICE51518.2020.00097>
- Maharani, A. (2025). Pemanfaatan Robotika untuk Meningkatkan Minat Belajar Sains pada Anak Sekolah. *Journal Sains and Education*, 3(01), 16-23.
- Masrifa, M. S., Muhajir, S. N., & Warliani, R. (2025). Penerapan Model *Inquiri* Terbimbing Berbasis Sensor Pada Materi Osilasi Bandul Untuk Meningkatkan Penguasaan Konsep Siswa. *Relativitas: Jurnal Riset Inovasi Pembelajaran Fisika*, 8(2), 95-110. <https://doi.org/10.29103/relativitas.v8i2.21670>
- Sailer, M., Maier, R., Berger, S., Kastorff, T., & Stegmann, K. (2024). Learning activities in technology-enhanced learning: A systematic review of meta-analyses and second-order meta-analysis in higher education. *Learning and Individual Differences*, 112, 102446. <https://doi.org/10.1016/j.lindif.2024.102446>
- Siswoyo, A., Noviyanto, A. H., Sulistyanto, M. P., Artanto, D., & Jiwatami, A. M. A. (2025). Implementasi Pembelajaran Berbasis Robotika untuk Penguatan Kompetensi STEM Guru dan Siswa Sekolah Dasar Negeri Tengkluk, Tegalsrejo, Gunung Kidul. *Jurnal Pengabdian Kepada Masyarakat Nusantara*, 6(4), 5713-5722. <https://doi.org/10.55338/jpkmn.v6i4.7622>
- Soares, C. C. S., Silva, L. A., Fernandes, A., González, G. V., Leithardt, V. R. Q., & Parreira, W. D. (2024). Intelligent sensors in assistive systems for deaf people: A comprehensive review. *PeerJ Computer Science*, 10, e2411. <https://doi.org/10.7717/peerj-cs.2411>
- Wijaya, A. Y. W., Dewi, I. P., Anori, S., & Samala, A. D. (2025). Development of AR-Based Learning Media for Sensor and Actuator Subjects using Assemblr Edu. *International Journal of Engineering and Collaborative Learning (IJECL)*, 2(1), 38-44.
- Yeung, K. L., Carpenter, S. K., & Corral, D. (2021). A Comprehensive Review of Educational Technology on Objective Learning Outcomes in Academic Contexts. *Educational Psychology Review*, 33(4), 1583-1630. <https://doi.org/10.1007/s10648-020-09592-4>
- Zangl, H. (2010). Capacitive sensors uncovered: Measurement, detection and classification in open environments. *Procedia Engineering, Eurosensor XXIV Conference*, 5, 393-399. <https://doi.org/10.1016/j.proeng.2010.09.130>
- Zribi, M., Pagliuca, P., & Pitolli, F. (2024). A Computer Vision-Based Quality Assessment Technique for the automatic control of consumables for analytical laboratories. *Expert Systems with Applications*, 256, 124892. <https://doi.org/10.1016/j.eswa.2024.124892>