ISSN : 2963-9158 E-ISSN : 2963-9166

Communautaire: Journal of Community Service
Vol. 04 No. 01 (2025) : 117-129
Available online at https://serambi.org/index.php/communautaire

Arduino Basic Training: Making a 12C LCD Running Text for Vocational High School Students

Vitri Tundjungsari[1]*, Ai Selpia Andita[2], Alfina Poetri Abdillah[3], Ivan Febrian Pratama[4]
[1,2,3,4]Universitas Esa Unggul, Special Capital Region of Jakarta, Indonesia
Email: vitri.tundjungsari@esaunggul.ac.id

Keywords:
Arduino, IoT, LCD I2C, Running Text, Wokwi

Corresponding Author

ABSTRACT

The development of technology in the era of Industry 4.0 demands increased competencies in the fields of the Internet of Things (IoT) and microcontrollers, especially for students in Vocational High Schools (SMK). Limited hardware and laboratory facilities are major obstacles in practical learning processes. Therefore, utilizing simulation platforms such as Wokwi becomes an effective solution to support microcontroller-based learning. This training aims to provide basic knowledge of Arduino usage through a simulation project of creating a running text on an LCD I2C using Wokwi for SMK students. The method applied combines theory and practice with a participatory approach, involving 25 participants from the Computer and Network Engineering (TKJ) and Visual Communication Design (DKV) departments. The evaluation was conducted using pre-tests and post-tests consisting of 10 multiple-choice questions to measure participants' understanding before and after the training. The results show a significant improvement in post-test scores, particularly in understanding basic concepts of IoT, microcontrollers, and Arduino programming practices. These findings prove that Wokwi is an effective simulation tool for enhancing basic microcontroller programming skills among beginners. Thus, this training model can serve as an alternative solution to support practical learning in schools with limited physical equipment.

Please cite this article in APA style as:
Tundjungsari, V., Andita, A. S., Abdillah, A. P., & Pratama, I. F. (2025). Arduino Basic Training: Making a 12C LCD Running Text for Vocational High School Students. *Communautaire: Journal of Community Service, 4*(1), 117-129. https://doi.org/10.61987/communautaire.v4i1.1080

INTRODUCTION

The rapid evolution of technology in the Industry 4.0 era has brought about significant transformations in the way industries function, particularly through the integration of digital systems such as the Internet of Things (IoT) (Budi et al., 2021; Chichekian et al., 2022; Chung & Lou, 2021). In this environment, IoT has emerged as a key driver of innovation and operational efficiency, connecting devices and systems for improved performance. One of the main components required for IoT systems is microcontrollers, which serve as the brain of many connected devices (Nakib, 2024). These microcontrollers, such as Arduino, have simplified the process of developing and controlling various IoT applications, from sensor-based systems to automated processes (Amusan & Ogunleye, 2024; Fadlil et al., 2024). For students in Vocational High Schools (SMK), learning how to program and use microcontrollers is essential to prepare them for future careers in the digital and automation industries (Budiarto et al., 2024; Bunyamin, 2023). However, despite the importance of such skills, many schools face challenges due to limited access to physical hardware and the high cost of setting up laboratories.

A major obstacle to IoT education, particularly in vocational schools, is the limited availability of physical hardware for students to experiment with. Studies have shown that practical exposure to microcontrollers is critical for learning programming skills, as theoretical instruction alone often does not suffice (Buchta et al., 2024; Ngaga et al., 2024). While many educators turn to traditional textbooks and lectures, these methods can lack the interactive component that makes learning more engaging and effective (Buchta et al., 2024; Koray & Duman, 2022). On the other hand, virtual learning platforms like Wokwi, which simulate microcontroller environments, offer a practical solution by allowing students to design, program, and troubleshoot IoT systems without needing physical hardware (Madzhi et al., 2024). This approach has been shown to enhance students' technical skills and understanding of IoT concepts, while also addressing infrastructure limitations in schools (Amri et al., 2022; Mazlan et al., 2023). The use of virtual simulators has the potential to democratize access to practical learning and improve learning outcomes for students in resource-constrained environments.

Vocational High Schools (SMK) in Indonesia play a crucial role in shaping the workforce by providing students with the skills needed for industrial and technological advancements. However, despite the increasing demand for professionals with IoT and microcontroller expertise, many vocational schools face significant challenges in delivering effective practical training due to limited access to necessary tools and infrastructure (Anam et al., 2023; Sudarsono et al., 2024). The lack of adequate laboratory facilities, especially in rural areas, is a pressing issue that hinders the ability of students to gain hands-on experience in developing IoT systems (Poo et al., 2023; Tariq et al., 2024). The social gap between urban and rural schools, where some schools have the resources to provide adequate training and others struggle, exacerbates the challenge (Faiz et al., 2023). This disparity in access to resources creates an urgent need for alternative educational solutions that can ensure equal opportunities for all students, regardless of their school's location or resources. Virtual simulation platforms like Wokwi, which provide a cost-effective and scalable solution, can be pivotal in bridging this gap and ensuring that all students have the opportunity to learn and develop relevant skills.

Virtual simulators like Wokwi allow students to design, test, and modify projects without needing physical hardware, making the learning process more flexible and accessible (Goshu & Ridwan, 2024). Reyes et al. (2024) indicates that the integration of simulators into the curriculum has led to improvements in students' technical skills and problem-solving abilities. Manyilizu (2023) demonstrated how Arduino platforms can be used to teach basic electronics and automation concepts. Pacadaljen (2024) emphasized the role of Arduino in fostering creativity and critical thinking in students. Asad et al. (2024), have explored the potential of simulators like Wokwi in supporting IoT-based education. These findings underscore the growing recognition of the benefits of virtual learning tools in vocational education and their potential to overcome infrastructural challenges.

Additionally, while previous research has highlighted the potential of virtual simulators, there is limited research that directly compares the effectiveness of different simulation tools or evaluates their impact on students' understanding of both hardware and software components. This study fills this gap by focusing on the use of Wokwi as a learning tool for creating basic Arduino projects, such as running text on an LCD, in vocational high schools. By examining this specific context, this research offers new insights into how virtual platforms can enhance basic IoT and microcontroller literacy in resource-constrained environments.

The primary objective of this study is to assess the effectiveness of Wokwi in teaching Arduino programming to vocational high school students, particularly in creating a running text on a 12C LCD. This training activity aims to improve students' understanding of microcontroller programming and familiarize them with the basic concepts of IoT. The research focuses on evaluating the impact and process of virtual simulation tools on students' ability to learn and apply IoT concepts, particularly when access to physical hardware is limited. This study also seeks to explore how virtual simulators like Wokwi can be integrated into the curriculum to overcome infrastructural barriers in vocational schools. To achieve these objectives, the study employs a participatory learning approach, combining theory and practice, and evaluates students' progress through pre-tests and post-tests. The research is designed to provide practical recommendations for educators on how to effectively implement virtual learning tools in the classroom, enhancing students' technical competencies and preparing them for future careers in technology and automation.

This research is original in its focus on the specific use of Wokwi to teach basic Arduino programming in vocational high schools, a relatively under-explored area in the current body of literature. The study's novelty lies in its emphasis on providing hands-on experience with microcontroller programming through simulation in a context where physical hardware is scarce. The research argument is that virtual simulators, particularly Wokwi, offer a practical and scalable solution for vocational education, enabling students to develop key skills in microcontroller programming without the need for expensive hardware. The findings of this study have the potential to inform policy decisions on the integration of virtual learning platforms into vocational education systems.

METHOD

The research method follows a systematic approach combining theory and practice to provide an engaging and comprehensive learning experience. The training is structured into a single session lasting approximately three hours, and participants actively engage in both theoretical discussions and practical exercises. The training is designed for beginners, focusing on foundational concepts of IoT and microcontroller programming (Keahey, 2021).

The research method is structured into three distinct phases: Introduction, Practical, and Evaluation. In the Introduction Phase, participants are first acquainted with foundational concepts essential for understanding the training content. This includes an overview of the Internet of Things (IoT), highlighting its benefits and real-world applications, followed by an introduction to the Arduino microcontroller, its components, and the integration of sensors, actuators, and the 12C LCD module.

The Practical Phase emphasizes hands-on learning, where participants actively engage with the Wokwi platform to apply the theoretical knowledge gained. They begin by designing a basic Arduino circuit that utilizes a 12C LCD to display running text. Participants then move on to programming tasks, either through the Arduino IDE or directly within the Wokwi platform, allowing them to write, test, and refine their code in a simulated environment. This phase reinforces the learning objectives through real-time application and experimentation.

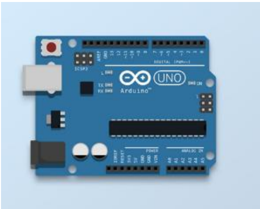
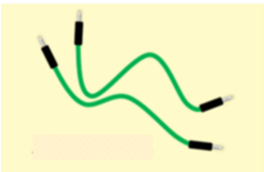
Finally, the Evaluation Phase is designed to measure the effectiveness of the training program. A pre-test is administered before the training begins to assess participants' baseline understanding of IoT, microcontrollers, and Arduino programming. After completing the training, a post-test is conducted to evaluate improvements in participants' knowledge and practical skills.

Table 1. Research Matrix

No	Research Activity	Method	Key Topics Covered	Tools and Materials
1	Pre-test	Face-to-face	Initial knowledge assessment on IoT, microcontrollers, and Arduino	Pre-test
2	Introduction to IoT and Arduino	Face-to-face	IoT, benefits, applications, and basic components of Arduino and LCD 12C	Presentation slides, handouts on IoT and Arduino basics
3	Introduction to Wokwi Platform	Face-to-face	Wokwi simulation platform basics and features	Computer with internet connection, Wokwi platform

4	Practical Session: Create 12C LCD Circuit	Face-to-face	Hands-on Arduino programming: designing a 12C LCD circuit	Arduino, LCD 12C module, jumper wires, Wokwi
5	Arduino Programming Practice	Face-to-face	Writing and testing code for Arduino-based projects	Arduino IDE or Wokwi platform
6	Post-test	Face-to-face	Assessment of post-training understanding	Post-test
7	Discussion and Evaluation	Online	Evaluation of the project implementation and coding	Feedback forms, and post-test results review

Table 2. Materials required

No	Component	Function	Description
1.	Arduino Uno 	The main microcontroller that runs the program	Can be programmed using C/C++ language via Arduino IDE or WOKWI as a simulator.
2.	LCD I2C 	LCD screen with I2C interface to display text.	The I2C module allows connection with only 4 cables: GND, VCC, SDA, and SCL
3.	Jumper Wire 	Connecting pins between components (e.g. Arduino to LCD)	Help with data and power flow between components

This study adopts a structured, participatory approach to teaching Arduino programming using the Wokwi simulation platform. The method combines theoretical lessons with hands-on exercises, ensuring that participants not only learn core concepts but also gain practical experience. The research evaluates the effectiveness of this training through a pre-test and post-test, assessing the improvement in participants' understanding of IoT and microcontroller concepts. The use of virtual simulation tools like Wokwi allows for flexible, resource-efficient learning, which is crucial for schools with limited access to physical hardware. The systematic training method provides a comprehensive, interactive, and scalable learning experience for vocational high school students.

FINDING AND DISCUSSION

Participant Enthusiasm and Preparedness

The enthusiasm of the participants for the training was evident from the outset, as each student came prepared with their personal laptops for the practice session. This eagerness reflects the growing interest in the Internet of Things (IoT) and microcontroller programming among vocational high school students. The readiness to engage with the virtual simulation platform Wokwi also indicates a positive attitude towards technology-based learning, which is crucial for adapting to Industry 4.0. The ability to use personal devices further enhanced the accessibility and flexibility of the learning process, enabling the participants to work independently and at their own pace. This is particularly important in resource-constrained environments where schools may not have enough computers or hardware to accommodate every student.

Figure 1. IoT Material Explanation

This training activity was held on Monday, May 26, 2025, at SMK Taman Harapan Bekasi and was attended by 25 participants consisting of grade X students from two vocational programs, namely Computer and Network Engineering (TKJ) and Visual Communication Design (DKV) (see Figure 1). The participants showed high enthusiasm for this activity, which was shown by the readiness of each participant to bring a personal laptop device as a practice medium. Prior to the presentation of the core material, participants first took a pre-test aimed to assess their initial knowledge regarding Arduino basics and microcontroller simulation. The pre-test consisted of 10 multiple-choice questions, each with four answer options, and were given 10 minutes to complete.

Figure 2. IoT Practice

After the presentation and practice, the participants proceeded to the post-test. The post-test is a questionnaire administered after the presentation is complete (see Figure 3). The questionnaire consists of the same questions and components as the pre-test (see Table 3).

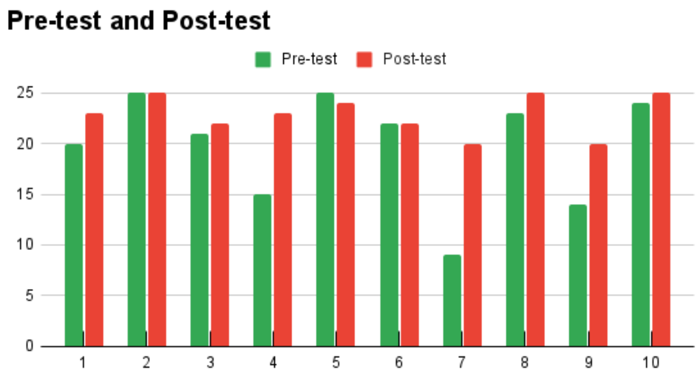


Figure 3. Question

Table 3. Pre-Test and Post-Test Question List

No	Question
1.	What is an IoT? Connected component that communicates through Internet Smart computer A game technology Internet connection
2.	Give me one example of IoT implementation at home? Smart lamp controlled via smart phone Table can move easily By close Smart door which open and close with movement sensor
3.	What is the component's name with function to collect data from environment? Projector Sensor Camera Alarm

4.	IoT stands for? Internet of Things Internet of Them Internet on Things Internet on Time
5.	What is the benefit of IoT? Support automation system Support manual works Reduce cost Reduce time
6.	What is the weakness of IoT? Require Internet Free of cost Cannot be controlled Big component
7.	Component that can run the command from the IoT system? Actuator Sensor Keyboard Screen
8.	Useful cloud computing technology for? Play music Store and process IoT data Print documents Speed up your laptop
9.	An example of a sensor in IoT is? Remote TV Temperature sensor Stores listric Speaker
10.	Can IoT be used in the health field for? Send a message Watch movies Monitor the patient's condition remotely Gaming

Based on the participants' pre-test and post-test results shown in Figure 3, it can be seen that there was a significant improvement in almost all questions after the participants participated in the training. The pre-tes t results still show several questions with a low level of understanding, particularly questions 4, 7, and 9, which had lower correct answers than the other questions. Significant improvements were seen in questions that previously had low scores, such as questions 4, 7, and 9, which experienced improvements.

The pre-test results provide valuable insights into the participants' baseline understanding of IoT, microcontrollers, and Arduino programming. Given that the participants were from different vocational fields (TKJ and DKV), it is expected that their familiarity with technical subjects such as IoT might vary. The fact that the majority of participants showed lower levels of understanding in questions related to IoT components, sensors, and the terminology of IoT (e.g., Question 4 on IoT) highlights the importance of focusing on these fundamental concepts during the training. The discrepancy in correct responses also indicates that, despite the growing relevance of IoT, foundational knowledge in this area might still be underemphasized in many school curricula.

The significant improvement in post-test scores reflects the effectiveness of the training, particularly in addressing gaps in participants' understanding. This finding suggests that the combination of theoretical knowledge and practical experience provided during the training was successful in helping students internalize complex concepts such as IoT, microcontrollers, and Arduino programming. The improvement in questions that initially had lower scores (e.g., questions 4, 7, and 9) further demonstrates that students were able to grasp key ideas, particularly those relating to the functions of IoT components, cloud computing, and the role of sensors. This reinforces the notion that interactive, hands-on training can enhance comprehension in technical subjects.

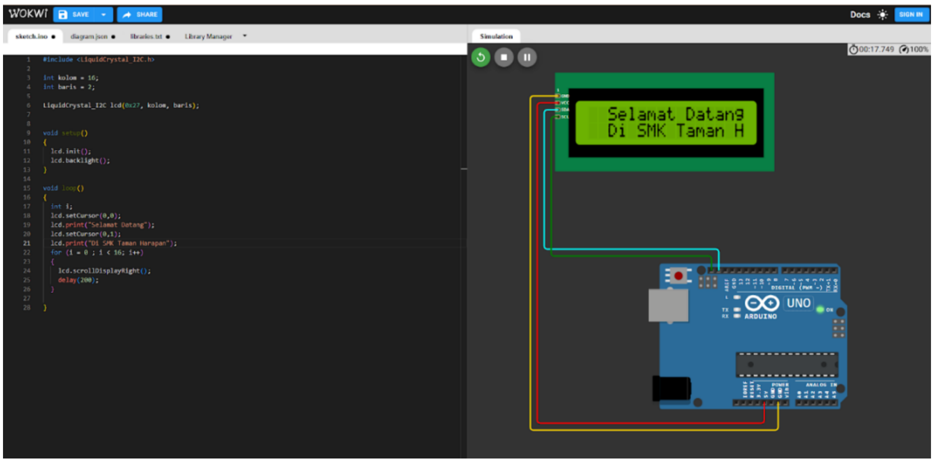


Figure 4. Wokwi Apps

The findings from this training suggest that hands-on simulation-based learning, using platforms like Wokwi (see Figure 4), is a highly effective way to teach complex technical subjects like IoT and microcontroller programming. This model can be easily replicated in other vocational schools, particularly those facing resource constraints. The results also suggest that future training programs should emphasize basic IoT concepts, especially for students with limited prior exposure. Additionally, integrating more interactive methods, such as collaborative projects or challenges, could further enhance engagement and understanding. This would not only improve learning outcomes but also help prepare students for future careers in technology and automation by offering them practical, real-world skills.

Discussion

One of the core concepts highlighted is the effectiveness of virtual simulation tools like Wokwi in facilitating the teaching of Arduino programming and IoT concepts. Wokwi creates a highly interactive environment where students can simulate real-world electronic systems without the need for physical components (Bunyamin, 2023; Fadlil et al., 2024). This approach is particularly advantageous for institutions with limited access to hardware, such as vocational schools, as it removes the cost barrier while maintaining the integrity of the learning experience. By enabling students to visualize and manipulate virtual circuits, Wokwi helps bridge the gap between theoretical knowledge and practical application.

The use of Wokwi also supports a deeper understanding of complex concepts through real-time interaction. Students can immediately see the effects of their code and circuit designs, which enhances engagement and promotes exploratory learning (Budi et al., 2021; Ngaga et al., 2024). This form of learning is far more dynamic than traditional classroom methods and encourages students to test, troubleshoot, and iterate on their designs. The ability to simulate sensor inputs and observe output behavior contributes to a more comprehensive grasp of how IoT systems function, making abstract principles more tangible and relatable.

Another essential concept is the integration of theoretical instruction with hands-on application. When students are given the opportunity to directly apply what they have learned, they are more likely to retain information and develop practical skills (Bunyamin, 2023; Chichekian et al., 2022). This method enhances cognitive links between concepts, helping students understand not only what IoT components do but also how and why they operate in specific ways. The improvement in understanding of terminology and sensor functionality reflects the power of contextual learning, where theory is constantly reinforced through real-world practice.

Active learning strategies stand out as particularly effective in the context of technical education. Passive instruction methods, such as lectures, often fail to engage students or build competence in applied tasks (Amri et al., 2022; Poo et al., 2023). In contrast, an interactive, learner-centered approach—where students are encouraged to experiment and explore—leads to more significant educational outcomes. Wokwi's simulated environment allows for this kind of learning by providing instant feedback and a safe space to make and learn from mistakes, which is vital for building confidence in technical subjects.

The relevance of microcontroller programming and IoT knowledge extends beyond academic achievement to real-world employability. As industries evolve under the influence of smart technologies and Industry 4.0, the demand for skilled professionals who can develop and maintain IoT systems continues to grow. Simulation-based learning platforms offer a scalable and accessible means to equip students with the skills needed to thrive in this environment. Teaching students to design and troubleshoot IoT applications not only prepares them for current job markets but also fosters a mindset of innovation and adaptability that is essential in a rapidly changing technological landscape.

CONCLUSION

Basic Arduino training with the topic of creating running text on an I2C LCD through the Wokwi platform given to students of SMK Taman Harapan Bekasi ran effectively. Based on the evaluation results of the pre-test and post-test, there was a significant increase in understanding among participants. This shows that the material presented, both through theoretical explanations and simulation practices, can help participants understand the basic concepts of IoT, Arduino, and the use of the Wokwi platform. This training not only provides theoretical understanding, but also practical experience that can improve students' competencies in the field of technology and microcontroller programming. Thus, the use of simulation platforms such as Wokwi can be an effective solution for microcontroller learning, especially in schools that have limited physical devices.

REFERENCES

Amri, S., Budiyanto, C. W., Fenyvesi, K., Yuana, R. A., & Widiastuti, I. (2022). Educational Robotics: Evaluating The Role of Computational Thinking in Attaining 21st Century Skills. *Open Education Studies*, *4*(1), 322–338. https://doi.org/10.1515/edu-2022-0174

Amusan, A. A., & Ogunleye, G. A. (2024). A Digital Twin-Enabled Smart Car Park Management System: Architecture and Impact on Emission Reduction. *FUOYE Journal of Engineering and Technology*, *9*(4), 629-635. https://doi.org/10.4314/fuoyejet.v9i4.10

Anam, M. K., Samsudi, S., & Supraptono, E. (2023). The Effect of Using a PLTS Trainer Kit with IoT Control on the Competence to Build Smart Buildings. *Journal of Vocational and Career Education*, *8*(1), 29-38.

Asad, M. M., Naz, A., Shaikh, A., Alrizq, M., Akram, M., & Alghamdi, A. (2024). Investigating the Impact of IoT-Based Smart Laboratories on Students' Academic Performance in Higher Education. *Universal Access in the Information Society*, *23*(3), 1135-1149. https://doi.org/10.1007/s10209-022-00944-1

Buchta, T., Martinec, T., Buchta, J., Hlava, J., & Tuma, P. (2024). Enhancing Microcontroller Programming Education with a 3D Virtual Factory Simulator. *IFAC-PapersOnLine*, *58*(9), 109-113. https://doi.org/10.1016/j.ifacol.2024.07.380

Budi, A. H. S., Juanda, E. A., & Fauzi, D. L. N. (2021). Implementation of Simulation Software on Vocational High School Students in Programming and Arduino Microcontroller Subject. *Journal of Technical Education and Training*, *13*(3), 108-114. https://doi.org/10.30880/jtet.2021.13.03.010

Budiarto, M. K., Karsidi, R., & Rahman, A. (2024). E-Learning Platform for Enhancing 21st Century Skills for Vocational School Students: A Systematic Literature Review. *Electronic Journal of E-Learning*, *22*(5), 76-90. https://doi.org/10.34190/ejel.22.5.3417

Bunyamin, B. (2023). Internet of Things for Project-Based Learning in "Vocational High School Building Village Program." *JINoP (Jurnal Inovasi Pembelajaran)*, *9*(2), 246-259. https://doi.org/10.22219/jinop.v9i2.26322

Chichekian, T., Trudeau, J., & Jawhar, T. (2022). Disrupted Lessons in Engineering Robotics: Pivoting Knowledge Transfer from Physical to Virtual Learning Environments. *Journal of Science Education and Technology*, *31*(5), 555-569. https://doi.org/10.1007/s10956-022-09973-0

Chung, C.-C., & Lou, S.-J. (2021). Physical Computing Strategy to Support Students' Coding Literacy: An Educational Experiment with Arduino Boards. *Applied Sciences*, *11*(4), 1830. https://doi.org/10.3390/app11041830

Fadlil, F., Wahono, T., Ismanto, E., & Khoirudin, A. (2024). Design of an Arduino-Based Automatic Sound Timer System for Mosques and Prayer Rooms. *Journal of Natural Sciences and Mathematics Research*, *10*(2), 158-166. https://doi.org/10.21580/jnsmr.v10i2.22293

Faiz, H., Al-Amin, M. F., Mundiri, A., & Fahmi, A. (2023). Transforming Organizational Quality Through Effective Administrative Training. *Communautaire: Journal of Community Service*, *2*(2), 157-167. https://doi.org/10.61987/communautaire.v2i2.352

Goshu, B. S., & Ridwan, M. (2024). A Receptor-Oriented Approach to Overcoming Universal Challenges in Science Education. *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal*, *7*(4), 187-204.

Keahey, J. (2021). Sustainable Development and Participatory Action Research: A Systematic Review. *Systemic Practice and Action Research*, *34*(3), 291-306. https://doi.org/10.1007/s11213-020-09535-8

Koray, A., & Duman, F. G. (2022). Subject-Oriented Educational Robotics Applications with Arduino in Science Teaching: Digital Dynamometer Activity in Accordance with 5E Instructional Model. *Science Activities*, *59*(4), 168-179. https://doi.org/10.1080/00368121.2022.2093824

Madzhi, N. K., M Thamrin, N., & Herman, S. H. (2024). Exploring the Potentials of Robotic Inclusive Education in Supporting Students with Disabilities. *Creative Practices in Language Learning and Teaching (CPLT)*, *12*(2), 125-135.

Manyilizu, M. C. (2023). Effectiveness of Virtual Laboratory vs. Paper-Based Experiences to the Hands-On Chemistry Practical in Tanzanian Secondary Schools. *Education and Information Technologies*, *28*(5), 4831-4848. https://doi.org/10.1007/s10639-022-11327-7

Mazlan, M. A., Azman, M. N. A., & Lin, V. T. A. (2023). Development of Scratch Applications for Virtual Smart Homes in Teaching Electronic Components in Electronic Design for Design and Tech Subjects. *Journal of Technology and Humanities*, *4*(2), 39-48. https://doi.org/10.53797/jthkkss.v4i2.5.2023

Nakib, A. M. (2024). Automated Water Management System with AI-Based Demand Prediction. *Informatyka, Automatyka, Pomiary w Gospodarce i Ochronie Środowiska*, *14*(4), 136-140. https://doi.org/10.35784/iapgos.6106

Ngaga, E., Siki, Y. C. H., Manehat, D. J., Bria, Y. P., & Nani, P. A. (2024). Pengenalan Dan Pelatihan Pemrograman Dasar IoT dengan Simulasi Wokwi Bagi Siswa TKJ SMKN Noemuti. *Jurnal Abdimas Bina Bangsa*, *5*(2), 1823-1831.

Pacadaljen, L. M. (2024). Hurdling Obstructions on Instructional Management of Science Teachers in Schools with Challenging Laboratory Resources. *Environment and Social Psychology*, *9*(10), 1-12. https://doi.org/10.59429/esp.v9i10.3027

Poo, M. C.-P., Lau, Y., & Chen, Q. (2023). Are Virtual Laboratories and Remote Laboratories Enhancing the Quality of Sustainability Education? *Education Sciences*, *13*(11), 1110. https://doi.org/10.3390/educsci13111110

Reyes, R. L., Isleta, K. P., Regala, J. D., & Bialba, D. M. R. (2024). Enhancing Experiential Science Learning with Virtual Labs: A Narrative Account of Merits, Challenges, and Implementation Strategies. *Journal of Computer Assisted Learning*, *40*(6), 3167-3186. https://doi.org/10.1111/jcal.13061

Sudarsono, B., Listyaningrum, P., Tentama, F., & Ghozali, F. A. (2024). Developing Learning and Training within Industry Model to Improve Work Readiness of Vocational High School Students. *International Journal of Evaluation and Research in Education*, *13*(3), 1731-1739. https://doi.org/10.11591/ijere.v13i3.26175

Tariq, R., Casillas-Muñoz, F., Hassan, S., & Ramírez-Montoya, M. (2024). Synergy of Internet of Things and Education: Cyber-Physical Systems Contributing Towards Remote Laboratories, Improved Learning, and School Management. *Journal of Social Studies Education Research*, *15*(2), 305-352.