JOVES (Journal of Vocational Education Studies)
VOL 8, No. 1, 2025, pp. 43-57
pISSN: 2614-7483 pISSN: 2614-7475 https://doi.org/10.12928/joves.v8i1.9449

Impact of Using Electro-pneumatic Training Kit on Improving Industrial Control System Skills of Vocational High School Students

[1]Herlin Setyawan, [2]Sukardi*, [3]Wiwik Rahayu, [4]Risfendra, [5]Nizwardi Jalinus, [6]Jonni Mardizal
Universitas Negeri Padang, Indonesia.

Email: [1] herlinsetyawan@student.unp.ac.id, [2] sukardiunp@ft.unp.ac.id*, [3] wiwikrahayu@ft.unp.ac.id, [4] risfendra@ft.unp.ac.id, [5] nizwardi@unp.ac.id, [6] jonni.mardizal@ft.unp.ac.id
* Correspondence author

ARTICLE INFO

Article history
Received Nov 29, 2024
Revised Jan 18, 2025
Accepted May 07, 2025

Keywords
Electropneumatic training kit
Vocational high school
Industrial control system
Student skills

ABSTRACT

Practical learning using simulation applications makes students unable to create natural industrial control systems, so the impact of the immaturity of practical skills that students must master becomes a problem in this study. Using simulation applications, students are only faced with ideal conditions and symbols of each component, so students cannot know the actual components of an industrial control system and how to solve real problems in this system. This study aims to examine the impact of using electro-pneumatic training kits in an industrial control system practicum. The actual experimental research method used in the study consisted of an experimental class with 28 students and a control class of 25 people. Data collection techniques used skill assessment rubrics with data analysis techniques, including independent t-tests and effect sizes. The results revealed a significant difference in the skills of experimental class students with the control class, where experimental class students had better skills. From the results of the effect size test, it is known that the electro-pneumatic training kit significantly improves students' industrial control system skills. Based on these results, the electro-pneumatic training kit proved to be a transformational educational tool, significantly improving students' skills in industrial control systems. The implication of this study is for schools to integrate technology-based training tools such as electro-pneumatic training kits; vocational education can provide practical experience that is more relevant to industry needs, improve students' work readiness, and strengthen technical skills that are urgently needed in today's modern job market and industrial world.

Email : joves@mpv.uad.ac.id
Website : http://journal2.uad.ac.id/index.php/joves

Introduction

The electro-pneumatic control system is one of the most rapidly growing control systems in the era of the Industrial Revolution 4.0. This control system has excellent flexibility in the application process. It can be integrated with various developing systems, such as robot manipulators, mobile robotics, and industrial automation, making the system work automatically. The electro-pneumatic control system consists of two main elements, namely the electro part and the pneumatic part, which differ from each other (Amudipe et al., 2024; Mojallizadeh et al., 2023). In the electrical element, the components used as a control system in an electro-pneumatic system can use a PLC (programmable logic controller) or microcontroller as the main controlling component. Meanwhile, the pneumatic element is a component used as an actuator or driver in a system using high-pressure wind as a source of power (Rojas Suárez et al., 2021; Szabo et al., 2020). So, this control system has significantly impacted technological advances in the industry. In addition, the rapid progress of this technology also affects the technology that must be used by educational institutions, especially in vocational high schools.

The development of technology in the industrial world significantly affects the learning process in vocational high schools because vocational high schools are one the educational institutions that will produce graduates with competencies according to industry needs (Sukardi et al., 2024). The Industrial Electronics Engineering department is one of the departments that produce competent graduates in electro-pneumatic control systems. This competency has been included in the industrial control system learning element with the learning outcome of applying PLC control circuits with electro-pneumatic components (Prapaskah et al., 2021). In order to produce graduates who have competencies relevant to the needs of the industry, vocational high schools often experience serious problems that have a significant impact on student competence. Currently, the problem that vocational high schools experience is the lack of relevance of the technology used for student learning because industrial technology has a high cost, and schools often experience obstacles (Lim & Kamin, 2023; Pereyras, 2020). The electro-pneumatic control system is one of the most complex systems, so students often have difficulty mastering the knowledge and skills that students must master. This difficulty is also caused by the fact that practicum equipment is not easily used by students in the learning process (Maarif & Suhartinah, 2018). In addition, irrelevant learning media used in the learning process will also make it difficult for students to master the competencies of the electromagnetic control system (Nazarova et al., 2024).

These problems are also experienced by Vocational High Schools (SMKN 1 Sumatera Barat). In the learning process of industrial control systems, the teacher uses an electro-pneumatic simulation application. In this application, students are only shown the concept of system work from the form of component symbols, so students do not know the actual use of components in the real world. The use of simulation applications also impacts the practical experience that students must get cannot be done. So, using simulation applications, students cannot apply PLC control circuits with electro-pneumatic components in real life (Aria et al., 2020). This limitation will have an impact on the skills that students will master. At the same time, students must possess this competency to produce graduates who are competent in applying PLC control circuits with electro-pneumatic components. As explained by (Yang et al., 2024), simulation applications can provide a basic understanding of an object studied by students but cannot provide actual practical experience to students. These are the shortcomings of simulation applications that will be applied in vocational schools. Meanwhile, vocational school students must master practical knowledge and skills in a competency they learn (Dezaki et al., 2022).

Thus, to overcome this problem, researchers apply electro-pneumatic training kit learning tools in the learning process of industrial control systems. This applied training kit has integrated electro elements as controllers and pneumatic elements as actuators. This training kit is expected to achieve the learning outcomes set out in the curriculum. Namely, students can apply PLC control circuits with electro-pneumatic components. Using a training kit will involve students in learning to get direct experience applying PLC control circuits with electro-pneumatic components. By using training kits in the learning process in improving students' knowledge and skills significantly (Aswardi et al., 2023; Pereyras, 2020; Prapaskah et al., 2021).

Thus, to overcome this problem, researchers apply electro-pneumatic training kit learning tools in the learning process of industrial control systems. This applied training kit has integrated electro elements as controllers and pneumatic elements as actuators. This training kit is expected to achieve the learning outcomes set out in the curriculum. Namely, students can apply PLC control circuits with electro-pneumatic components. Using a training kit will involve students learning to get direct experience applying PLC control circuits with electro-pneumatic components. Using training kits in the learning process significantly improves students' knowledge and skills.

The development and application of electro-pneumatic training kits in the learning process have been carried out by several previous researchers as done by (Dezaki et al., 2022; Nazarova et al., 2024) developing electro-pneumatic training kits in the form of conveyor systems and robot manipulators that replicate systems in industry so that students can understand the concept of applying electro-pneumatic control systems in industry. However, the research is still limited to testing the system's performance alone and has not conducted further studies on how the impact on students' knowledge and skills. The same thing was also done by (Bakar et al., 2024; Sukir et al., 2021), who developed an applicable training kit by industrial applications but also only examined the performance of the training kit developed. Training kits used in the learning process operate correctly and must significantly impact student knowledge and skills. Because this tool supports the learning process in vocational high schools, it should also significantly benefit student competence.

The impact of using electro-pneumatic training kits in the learning process (Pereyras, 2020) states that electro-pneumatic training kits are very acceptable in terms of architecture, efficiency, instructional capabilities and protection features, and student application. In addition, the electro-pneumatic training kit has also been declared very feasible to use in the learning process in vocational schools (Prapaskah et al., 2021). In-depth research conducted by (Aswardi et al., 2023) states that applying training kits in the learning process in vocational schools can improve students' practical skills. Based on previous studies, it can be seen that there are still few researchers who examine the impact of training kits on improving the practical skills that students will master. Research conducted by (Aswardi et al., 2023) studied the impact of training kits on students' practical skills in using PLCs to control 3-phase motors instead of students' electro-pneumatic system skills. Based on this research gap, the researcher aims to examine the impact of the electro-pneumatic training kit on the practical skills of implementing a PLC control circuit with electro-pneumatic components that must be mastered by students majoring in Industrial Electronics Engineering. The research will highlight the importance of applying electro-pneumatic training kits in the learning process to improve students' practical skills. Practical skills are one of the primary skills that vocational students must possess.

Method

The true experimental research method was used to carry out this research, which in the implementation process used two trial classes, namely the experimental class and the control class. The experimental class uses an electro-pneumatic training kit, and the control class uses simulation applications to learn about industrial control systems. The research method steps are shown in Table 1. Table 1 shows that the experimental class (O_1) and the control class (O_3) at the initial stage before the learning process carried out both pretest assessments. After that, in the learning process, the experimental class used the electro-pneumatic training kit (X), while the control class used the Festo FluidSIM simulation application as usual in the learning process. After going through the industrial control system learning process for six meetings, students will be tested again to find out the final scores of students in both the experimental class (O_2) and the control class (O_4) (Cahuc & Hervelin, 2024; Chutima & Khotsaenlee, 2022). The research subjects used in this study were students majoring in Industrial Electronics Engineering at SMKN 1 Sumter Barat, with 53 students. The students will be divided into the experimental class, totaling 28 students, and the control class of 25 students. Students included in the study are in eleventh grade and do industrial control system learning. The 53 students consisted of 6 female students and 47 male students.

Table 1. True experimental research method

Class	***Pretest***	***Treatment***	***Posttest***
Experiment	O_1	X	O_2
Control	O_3	-	O_4

Because this study aims to determine the impact of electro-pneumatic training kits on improving students' industrial control system skills, the instrument used to measure student skills is a student performance assessment rubric arranged in the form of a questionnaire. Each assessment criterion in the questionnaire will be assessed using the Likert scale concept with alternative answers from 1 to 5 (Setyawan, Sukardi, Risfendra, et al., 2024). Thus, the assessment of student skills is seen from the first four variables of understanding components, translating circuit drawings, practicing and implementing the system, and operating and testing the system. The skills assessment instrument used has undergone the validity test stage, namely the content validity test, which experts in research instruments assess. Three experts in research instruments carried out the assessment, and the test results were analyzed using Aiken's V formula.

The Aiken's V value obtained based on the results of this test is 0.92, which means that the assessment instrument for measuring student skills is valid for assessing students' industrial control system skills (Yanto et al., 2023). After the data on students' industrial control system skills is obtained, the data is first analyzed prerequisites because the tests used in this study are parametric analyses. There are two prerequisite analyses used, namely the data normality test and the data homogeneity test; because there are two classes used in this study, namely the experimental class and the control class, this prerequisite test must be fulfilled to increase the validity of the research data (Setyawan, Sukardi, Diati, et al., 2024). The table 2 shown student skill assessment instruments.

Table 2. Student skill assessment instrument grids

Assessment Variable		***Assessment Indicator***
Component Understanding	1.1	Students can select input components used to create an electro-pneumatic control system.
	1.2	Students can select output components used to create an electro-pneumatic control system.
	1.3	Students can select electrical control components used to create an electro-pneumatic control system.
	1.4	Students can select pneumatic control components used to create an electro-pneumatic control system.
Translating circuit drawings	2.1	Students can interpret the electrical power circuit drawing of the electro-pneumatic control system.
	2.2	Students can interpret the electrical control circuit drawing of the electro-pneumatic control system.
	2.3	Students can translate pneumatic circuit drawings.
System Assembly and Implementation	3.1	Students can make the input circuit of the electro-pneumatic control system.
	3.2	Students can make the output circuit of the electro-pneumatic control system.
	3.3	Students can make pneumatic circuits of electro-pneumatic control system.
	3.4	Students can ensure the proper connection of pneumatic cables and hoses.
System Operation and Testing	4.1	Students can operate electro-pneumatic systems according to procedures.
	4.2	Students can test the components of the electro-pneumatic system to ensure its functionality.
	4.3	Students can detect faults or malfunctions in electro-pneumatic systems.
	4.4	Students can perform calibration on electro-pneumatic control systems.

After going through this test, the data can be analyzed further to get the results of this study. Two types of data analysis techniques are used in this study: the independent t-test and the effect size test. Independent t-test testing is used to determine the difference in learning outcomes between control class students and experimental classes. The effect size test is used to determine how much the impact of the electro-pneumatic training kit can improve the industrial control system skills of Industrial Electronics Engineering students (Risfendra et al., 2023; Setyawan, Sukardi, Risfendra, et al., 2024).

Result and Discussion

Research Results

The electro-pneumatic training kit in this research is used in the learning process of industrial control systems in the learning outcomes of applying programmable logic controller (PLC) control circuits with electro-pneumatic components. From Figure 1, it can be seen that this training kit has nine main components: (1) push button, (2) pilot lamp, (3) inductive proximity sensor, (4) 24 VDC

Email : joves@mpv.uad.ac.id
Website : http://journal2.uad.ac.id/index.php/joves

power supply, (5) limit switch sensor, (6) double action cylinder, (7) 5/2 single solenoid valve, (8) miniature circuit breaker, and (9) programmable logic controller. The integration of the components in this training kit refers to the learning outcomes of industrial control systems that must be mastered by students majoring in industrial electronics engineering. During the learning process in the experimental class, students used the training kit to conduct the electro-pneumatic industrial control system practicum, as shown in Figure 2.

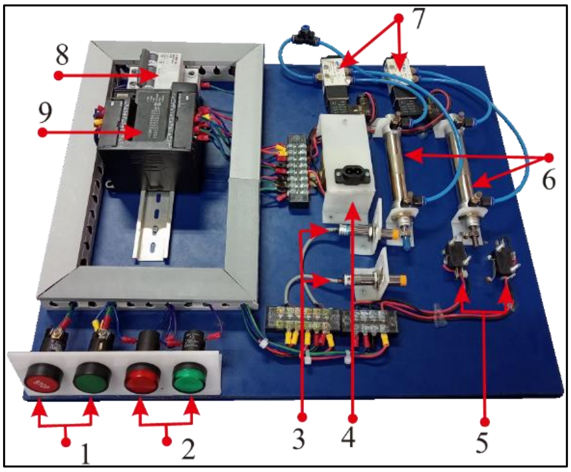

Fig 1: Electro-pneumatic training kit


Fig 2: Learning process

During the research process that was carried out in this study, pretest and posttest data on students' industrial control system skills were obtained, as shown in Table 3. Based on this data, the average value of each class, as well as both the control class and the experimental class, can be known. The average pretest value of the control class was 67.560, and the posttest was 73.920. The average pretest value of the experimental class was 68,107, and the posttest was 82,214. The experimental class is superior to the control class based on the average posttest score. From Table

3, it is also known that the results of data normality testing, where the control class pretest data get a significance value of 0.184 and the significance value of the posttest data is 0.197. Thus, it can be interpreted that the control class pretest and posttest data are typically distributed. Likewise, the pretest and posttest data get a significance value of 0.084 (pretest) and 0.140 (posttest). Thus, it can also be interpreted that the experimental class pretest and posttest data are typically distributed.

Table 3. Data normality test results

		Control Class		**Experiment Class**	
		Pretest	**Posttest**	**Pretest**	**Posttest**
N		25	25	28	28
Normal Parameters	Mean	67.560	73.920	68.107	82.214
	Std. Deviation	4.744	5.986	5.820	4.399
Most Extreme Differences	Absolute	0.145	0.143	0.155	0.144
	Positive	0.145	0.143	0.117	0.144
	Negative	-0.105	-0.113	-0.155	-0.089
Test Statistic		0.145	0.113	0.155	0.144
Sig. (2-tailed)		0.184	0.197	0.084	0.140

The second data requirement test is the homogeneity test, and the results of this test are shown in Table 4. From the downstream testing, it can be seen that the pretest value data gets a significance value of 0.213, and the posttest value data gets a significance value of 0.236. Based on these results, the pretest and posttest data obtained are both homogeneous. The results of this test indicate that both pretest and posttest data are taken from the same population source. This requirement must be met if independent t-test testing is used. After doing this test, all data in this study meet the requirements of normality and homogeneity of data. So, this research data can be used for further analysis, namely the independent t-test and effect size test, to answer the objectives of this study.

Table 4. Data homogeneity test results

Data	***Levene Statistic***	***df1***	***Df2***	***Sig.***
Pretest	1.591	1	51	0.213
Posttest	1.438	1	51	0.236

To answer the objectives of this study, the first data analysis used was the independent t-test analysis technique, with the results as shown in Table 5. Based on Table 5, it is known that the pretest and posttest data of the experimental and control classes were analyzed first. From the pretest value analysis results, it is known that the t-value equal variances assumed obtained is 0.372, which is smaller than the t-table value (0.372 < 1.675). The equal variances assumed significance value obtained is more significant than 0.05 (0.711 > 0.05). Thus, there is a difference between the experimental class students' initial skills and the control class. Further analysis was carried out on the data of students' pretest scores after carrying out the learning process in both the experimental and control classes. The test results show that the t-value Equal variances assumed obtained is 5.789 greater than the t-table value (5.789> 1.675). While the significance value obtained of 0.000 is smaller than the maximum significance limit value (0.000 <0.05). Thus, the industrial control system skills of the experimental class are significantly different from those of the control class, so the skills of the experimental class students are better than those of the control class.

Table 5. Independent t-test results

Data		***t-value***	***df***	***Sig. (2-tailed)***	***CI = 95 %***	
					Lower	***Upper***
Pretest	Equal variances assumed	0.372	51	0.711	-2.403	3.498
	Equal variances not assumed	0.377	50.608	0.708	-2.369	3.464
Posttest	Equal variances assumed	5.789	51	0.000	5.418	11.171
	Equal variances not assumed	5.691	43.703	0.000	5.356	11.232

After it is known that the skills of experimental class students are significantly higher than those of the control class, an analysis is carried out to determine how much impact the electro-pneumatic training kit has on students' industrial control system skills. This analysis technique uses the effect size equation, whose results are shown in Table 6. The analysis results show that the average skill value of experimental class students is 82.214 with a standard deviation of 4.399, and the average skill value of control class students is 73.920 with a standard deviation of 5.986. From this average value, it is known that the experimental class has better skills than the control class; the difference in value between students is also tiny. If examined more deeply, the effect size value obtained is 1.579; if interpreted in Cohen's d category, this value is in the large category. The electro-pneumatic training kit dramatically impacts students' industrial control system skills.

Table 6. Hasil analisis effect size

Posttest Value	***Number of Sample***	***Mean***	***Std. Deviation***	***Effect Size Value***	***Criteria***
Experiment Class	28	82.214	4.399	1.579	Large
Control Class	25	73.920	5.986		

Discussion

An electro-pneumatic training kit is a tool students use to carry out industrial control system practicum. The concept used in this training kit is that the components used both in the electro element as a controller and the pneumatic element as an actuator are the same as the components used by the industry to control the machine. So, the theory and practicum learning process is relevant to what students will do in the industry. Using electro-pneumatic training kits in the learning process, students will work directly to carry out an industrial control system practicum. Thus, mastery of student competencies will increase significantly (Tafakur et al., 2020). Using electro-pneumatic training kits in the learning process, students will be equipped with practical experience to create a system simulation in the industry. By using this training kit, students can develop technical skills, such as control logic design, system hardware configuration, and controller programming directly (Dezaki et al., 2022; Sukir et al., 2021). These concepts are what make students' practical skills can be significantly improved by using training kits in the learning process.

In line with this concept, the results of research data processing also show that using training kits in the learning process can significantly improve students' industrial control system skills, based on independent t-tests. In addition, the electro-pneumatic training kit also has a significant impact on improving student skills, based on the results of the effect size test. These two analyses reinforce the usefulness of the training kit when used in the learning process. These results are also supported by previous research, stating the importance of learning that involves students actively in the practicum process (student-centered learning) to improve students' mastery of practical skills (Bakar et al., 2024; Lim & Kamin, 2023). Using electro-pneumatic training kits in the learning process gives students a direct experience of how industrial control system components work in real-time. Using training kits in the learning process can bridge the gap between the theory learned and direct practicum by the theory learned; this concept can ensure students are better prepared to accept the challenges of specific tasks in the industrial world (Efendi & Abadi, 2021; Nazarova et al., 2024).

Using electro-pneumatic training kits in the learning process will also encourage students' creativity and critical thinking; students not only understand how to use each component but can integrate all components to become a unified industrial control system. In addition, equipping students with the theoretical concepts of industrial control systems will improve students' understanding of carrying out practicum using training kits (Avcı, 2024; Kikuchi et al., 2024). In addition, using training kits in the learning process can also increase student involvement so that the learning process is student-centered. Thus, the interactive nature of training kits in the learning process can increase students' curiosity and maintain their attention in the learning process to create a dynamic learning atmosphere (Pereyras, 2020; Prapaskah et al., 2021).

The use of training kits in the learning process will also have an impact on students' problem-solving skills. Using the training kit will make students more effective in seeing and fixing technical problems in an industrial control system. This shows that practicum, or repeated interaction with actual conditions carried out by students during practicum, helps students increase their confidence and ability to solve problems. These are among the skills in high demand in the industrial world (Alshammari, 2023; Mukul & Büyüközkan, 2023). This emphasizes that using electro-pneumatic training kits in the learning process at vocational schools can increase the relevance of graduate competencies to industry needs. Given that industrial automation and electro-pneumatic systems are one of the main parts of modern manufacturing, improving these skills will increase students' competitiveness in the industrial and working world (Poláková et al., 2023).

The research is also inseparable from the research limit based on the positive results obtained. The electro-pneumatic training kit that is applied can be through a simulation of the existing wiring system in the industry that has not been made like a replica of a system in the industry. In addition, the impact of the training kit is only studied based on one school, so a limited research sample is a limitation in this study. In the future, there will be a training kit development that replicates a system in the industry because using a training kit that is more similar to what students will do in the industry will increase students' knowledge and practical skills. Applying electro-pneumatic training kits from various schools or regions is also recommended for this study. To determine the overall impact of electro-pneumatic training kits in improving students' industrial control system skills. In addition, schools can also consider integrating electro-pneumatic training kits in the industrial control system learning process, which will make the learning process more dynamic and improve student skills.

Conclusion

Based on the two test results that have been carried out, first, from the independent t-test results, it can be concluded that there is a significant difference between the skills of experimental class students and the control class. Thus, it is known that the control system skills of experimental class students are higher than those of the control class. Based on the second test's results, namely the effect size test, the electro-pneumatic training kit developed significantly improves students' industrial control system skills. Based on these results, the electro-pneumatic training kit proved to be a transformational educational tool, significantly improving students' skills in industrial control systems. It bridges the gap between theoretical learning and practical application, making vocational education more relevant and impactful. So the implication of carrying out this research is that schools can integrate technology-based training tools such as electro-pneumatic training kits, vocational education can provide practical experiences that are more relevant to industry needs, improve students' work readiness, and strengthen technical skills that are urgently needed in today's modern job market and industrial world.

References

Alshammari, S. H. (2023). The Effects of Technical Skills, Attitudes, and Knowledge on Students' Readiness to Use 4.0 Industrial Revolution Technologies in Education. International Journal of Education in Mathematics, Science and Technology, 12(1), 40–52. https://doi.org/10.46328/ijemst.3638

Amudipe, S. O., Kayode, J. F., Adaramola, B. A., Olatunbosun, O. J., & Afolalu, S. A. (2024). Simulation of transient response of PID controller in an automated electro-pneumatic system using a single-acting cylinder in a clinical ventilator. Heliyon, 10(7), e27799. https://doi.org/10.1016/j.heliyon.2024.e27799

Aria, M., Utama, J., Fauzia, F., Rizal, M., Fahmi, M., & Yudha, M. (2020). Virtual Simulation System with Various Examples and Analysis Tools for Programmable Logic Controller Training. IOP Conference Series: Materials Science and Engineering, 879(1), 012108. https://doi.org/10.1088/1757-899X/879/1/012108

Aswardi, A., Putra Yanto, D. T., Dewi, C., Zaswita, H., Kabatiah, M., & Kurani, R. (2023). Human Machine Interface-Based Control Training Kit as Innovative Learning Media to Enhance Students' Automation Control Skills in the Industry 4.0 Era. TEM Journal, 12(4), 2157–2165. https://doi.org/10.18421/TEM124-26

Avcı, F. (2024). Effects of robotic module-supported experimental activities with the cooperative learning method on student achievement, 21st-century skills, and students' opinions. Journal of Computer Assisted Learning, 40(5), 2325–2338. https://doi.org/10.1111/jcal.13030

Bakar, S. S. A., Ahmad, W. N. W., Zubir, N. A. M., Rui, T. J., & Ahmad, W. M. W. (2024). Automatic Thread Insertion Kit Sewing (ATIKs) Device for Vocational Fashion Design Student: Practical Sewing Application. Journal of Advanced Research in Applied Sciences and Engineering Technology, 34(1), 238–248. https://doi.org/10.37934/ARASET.34.1.238248

Cahuc, P., & Hervelin, J. (2024). The effect of workplace vs school-based vocational education on youth unemployment: Evidence from France. European Economic Review, 162(November 2023), 104637. https://doi.org/10.1016/j.euroecorev.2023.104637

Chutima, P., & Khotsaenlee, A. (2022). Multi-objective parallel adjacent U-shaped assembly line balancing collaborated by robots and normal and disabled workers. Computers & Operations Research, 143, 105775. https://doi.org/https://doi.org/10.1016/j.cor.2022.105775

Dezaki, M. L., Hatami, S., Zolfagharian, A., & Bodaghi, M. (2022). A pneumatic conveyor robot for color detection and sorting. Cognitive Robotics, 2(February), 60–72. https://doi.org/10.1016/j.cogr.2022.03.001

Efendi, A., & Abadi, A. H. (2021). Manufacturing of suitcase electropneumatic trainer kit. Journal of Physics: Conference Series, 1833(1). https://doi.org/10.1088/1742-6596/1833/1/012003

Kikuchi, S., Komai, H., Obara, H., Abe, K., Ohki, T., Mii, S., Park, Y., Hoshina, K., Yamaoka, T., Deguchi, J., Kodama, A., Kokubo, T., Kaneko, K., Guntani, A., Miyama, N., Omine, T., Fujimura, N., Kan, C.-D., Kim, J. Y., … Azuma, N. (2024). Evaluation of a web-based surgical training approach and insights from the Distal Bypass Competition 2021 using a simulator kit. JVS-Vascular Insights, 2, 100149. https://doi.org/10.1016/j.jvsvi.2024.100149

Lim, S. F., & Kamin, Y. (2023). The Development of Mobile AR-Based Module for Teaching and Learning Pneumatic System: A Needs Analysis. Pertanika Journal of Social Sciences and Humanities, 31(1), 41–56. https://doi.org/10.47836/PJSSH.31.1.03

Maarif, E. S., & Suhartinah, S. (2018). Compact Portable Industrial Automation Kit for Vocational School and Industrial Training. IOP Conference Series: Materials Science and Engineering, 384(1). https://doi.org/10.1088/1757-899X/384/1/012011

Mojallizadeh, M. R., Brogliato, B., Polyakov, A., Selvarajan, S., Michel, L., Plestan, F., Ghanes, M., Barbot, J. P., & Aoustin, Y. (2023). A survey on the discrete-time differentiators in closed-loop control systems: Experiments on an electro-pneumatic system. Control Engineering Practice, 136(September 2022), 105546. https://doi.org/10.1016/j.conengprac.2023.105546

Mukul, E., & Büyüközkan, G. (2023). Digital transformation in education: A systematic review of education 4.0. Technological Forecasting and Social Change, 194(August 2022), 122664. https://doi.org/10.1016/j.techfore.2023.122664

Nazarova, O., Osadchyy, V., Hutsol, T., Glowacki, S., Nurek, T., Hulevskyi, V., & Horetska, I. (2024).

Mechatronic automatic control system of electropneumatic manipulator. Scientific Reports, 14(1), 1–10. https://doi.org/10.1038/s41598-024-56672-4

Pereyras, J. G. (2020). Acceptability of the Basic Electro-pneumatic Control Trainer. International Journal of Emerging Trends in Engineering Research, 8(7), 3157–3159. https://doi.org/10.30534/ijeter/2020/46872020

Poláková, M., Suleimanová, J. H., Madzík, P., Copuš, L., Molnárová, I., & Polednová, J. (2023). Soft skills and their importance in the labour market under the conditions of Industry 5.0. Heliyon, 9(8), e18670. https://doi.org/10.1016/j.heliyon.2023.e18670

Prapaskah, Y. A., Permata, E., & Fatkhurrokhman, M. (2021). Trainer Kit Pneumatik sebagai Media Pembelajaran pada Mata Kuliah Mekatronika di Program Studi Pendidikan Vokasional Teknik Elektro Untirta. Elinvo (Electronics, Informatics, and Vocational Education), 5(2), 149–159. https://doi.org/10.21831/elinvo.v5i2.33798

Risfendra, Yoga Maulana Putra, Setyawan, H., & Yuhendri, M. (2023). Development of Outseal PLC-Based HMI as Learning Training Kits for Programmed Control Systems Subject in Vocational Schools. Jurnal Pendidikan Tambusai, 7(1), 4397–4406. https://proceeding.unnes.ac.id/veic/article/view/2883

Rojas Suárez, J. P., Pabón León, J. A., & Orjuela Abril, M. S. (2021). Development of an electro-pneumatic system for the practical training of pneumatic processes in the university environment. Journal of Physics: Conference Series, 2073(1), 012016. https://doi.org/10.1088/1742-6596/2073/1/012016

Setyawan, H., Sukardi, S., Diati, L. S., Fitri, Y. I., Ambiyar, A., & Rianto, D. (2024). Enhancing basic computer network learning outcomes of vocational high school students by implementing a video-based learning model. Jurnal Pendidikan Teknologi Kejuruan, 7(1), 11–21. https://doi.org/10.24036/jptk.v7i1.35023

Setyawan, H., Sukardi, S., Risfendra, R., Putri, M. Y., Oktavia, V., Ambiyar, A., & Wulansari, R. E. (2024). Impact of Variable Speed Drive Jobsheet Integrated with Project-Based Learning Model on Electric Motor Control Skills of Vocational Students. INVOTEK: Jurnal Inovasi Vokasional Dan Teknologi, 23(3), 175–186. https://doi.org/10.24036/invotek.v23i3.1155

Sukardi, Setyawan, H., Risfendra, Usmeldi, & Department, D. T. P. Y. (2024). Effectiveness of Robotic Technology in Vocational Education: A Meta-Analysis. International Journal of Information and Education Technology, 14(4), 521–532. https://doi.org/10.18178/ijiet.2024.14.4.2073

Sukir, Sa'adilah, Hartoyo, Sunaryo, & Saifullizam, B. P. (2021). Performance of Trainers kits for Industrial Automation Based on Programmable Logic Controllers. Journal of Physics: Conference Series, 2111(1), 012040. https://doi.org/10.1088/1742-6596/2111/1/012040

Szabo, A., Becsi, T., & Gaspar, P. (2020). Control Design and Validation for Floating Piston Electro-Pneumatic Gearbox Actuator. Applied Sciences, 10(10), 3514. https://doi.org/10.3390/app10103514

Tafakur, Sukaswanto, Solikin, M., & Wardani, F. R. (2020). The Development of Training Kit For Basic Electronic Control on Automotive Field. Journal of Physics: Conference Series, 1700(1), 012069. https://doi.org/10.1088/1742-6596/1700/1/012069

Yang, B.-H., Chung, C.-Y., Li, Y.-S., & Lu, C.-F. (2024). A cooperative learning intervention for improving a simulation-based paediatric nursing course: A quasi-experimental study. Nurse Education in Practice, 80(199), 104149. https://doi.org/10.1016/j.nepr.2024.104149

Yanto, D. T. P., Eliza, F., Ganefri, Sukardi, Hastuti, Kabatiah, M., & Andrian. (2023). Android-Based Courseware as an Educational Technology Innovation for Electrical Circuit Course: An Effectiveness Study. International Journal of Information and Education Technology, 13(12), 1835–1843. https://doi.org/10.18178/ijiet.2023.13.12.1996