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The Effect of Using a PLTS Trainer Kit with IoT Control on the Competence to Build Smart Buildings

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Abstract

One principle of vocational education formulated by Prosser is that vocational education will be effective if the student's work environment is a replica of the work environment and tasks carried out with tools, methods and machines that are also used in the wo rld of work. development of learning media by integrating PLTS and IoT trainer kits where PLTS is needed to support learning about energy installations and lighting installations, system control and IoT. This development is in order to keep up with developments in world industry. This research aims to develop and analyze the feasibility and effectiveness of an Internet Of Things (IoT)-controlled Solar Power Generator (PLTS) trainer kit. The research method employed is a quantitative approach using the Research and Development (RnD) method, following the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation). Data collection is conducted through questionnaires and tests. Questionnaires are used to assess the suitability of the media by media experts and subject matter experts, while tests are used to measure student competence improvement before and after the treatment. The research results indicate that the PLTS trainer kit with IoT control has high feasibility, with a score of 87% from media experts and 88% from subject matter experts, categorizing it as highly feasible. The t-test results show a significant increase in student competence, with an average pre-test score of 58.4 and a post-test score of 76.16. Statistical analysis reveals a calculated t-value of -7.79 and a tabulated t-value of 2.00. Therefore, the null hypothesis (H0) is accepted, indicating a significant difference between the pre-test and post-test.

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INTRODUCTION

Renewable energy (RE) is energy generated from sustainable sources. These energy sources include wind, water, solar, and so on. Indonesia has a considerable potential for renewable energy, reaching 413,818 MW. Solar energy alone has a potential of 207,898 MW, which is the largest among other renewable energy potentials. However, in practice, solar energy has not been widely adopted by the general public, partly due to a lack of awareness about Solar Power Generation (PLTS) technology (Harahap et al., 2021).

In addition to RE the industrial world has experienced rapid advancement. This progress encompasses advancements in machinery technology, digital technology, human resources, and more. In the past, industrial production processes were predominantly manual, but now automation has simplified everything through machines. This automation system has further evolved into cyber-physical systems, defined as the connection between machines, devices, sensors, humans in the industry, all integrated into a single platform through the Internet, also known as the Internet of Things (IoT) (Adam et al., 2022). More specifically, IoT is also referred to as Supervisory Control And Data Acquisition (SCADA), which serves as a supervisor, controller, and data acquisition system for interconnected devices. SCADA is a subset of IoT with a focus on industrial applications (Yadav & Paul, 2021).

Vocational education in Indonesia emphasizes practical learning. Human sensory abilities indicate that people can remember 20% of what they hear, 50% of what they see, and 80% of what they see, hear, and do simultaneously (Yuliarsih et al., 2022). This aligns with one of the principles of vocational education formulated by Prosser, which states that vocational education is effective when the student's working environment replicates the real work environment, and tasks are performed with tools, methods, and machines used in the workplace (Aqsha et al., 2020).

In the realm of education, instructional media is a crucial factor in supporting effective learning. Instructional media refers to tools used by teachers to convey educational materials to students (Afrizal & Suprianto, 2018). The use of instructional media has a significant impact on students' understanding of the material presented by teachers (S. Adam & T.S, 2015). Instructional media encompasses all tools used to facilitate teaching, including audio, visual, audiovisual materials, props, and trainers.

Trainers are one of the instructional media used in practical learning. Trainers are a set of tools that represent real-world equipment and assist in the learning process (M. A. Adam et al., 2022). Trainers provide students with hands-on experience by presenting practical equipment that closely resembles the real thing but with simplified usage processes. The use of trainers is expected to enhance students' competence, especially in practical skills.

Technological advancements go hand in hand with the development of instructional media. These technological advancements also influence the education sector, including the use of Information Technology-based instructional media (Anggraini et al., 2022). Traditional teaching, where teachers explain while students passively listen, is no longer considered relevant and effective. Instructional media serve as aids to facilitate the conveyance of knowledge to students (Celestino Doanwilmon & Aswardi, 2020). The use of technology in instructional media makes the learning process more effective and efficient, leading to easier achievement of learning goals (Noor Jannah et al., n.d.).

The development of PLTS and IoT trainers has been explored in previous research. PLTS trainers have been developed in modular form, with each component separately labeled to facilitate use (Harahap et al., 2021). IoT trainers have also been developed based on Arduino, with the addition of esp8266 modules and a set of inputs and outputs for control (Wardiyanto & Yundra, 2019). In previous research, these trainers were not integrated, even though both technologies can be integrated.

Based on the above description, there is a need to develop instructional media for the basic competency of building smart lighting control systems that integrate energy installation, lighting installation, and control installation trainers.

Therefore, the researcher has undertaken development by integrating PLTS and IoT trainer kits, where PLTS supports energy installation and lighting installation learning, while IoT supports control installation learning.

METHOD

In this research, the Research and Development (R&D) research method is used. This method is aimed at producing a product and testing its effectiveness (Junaidi & Suprianto, 2020). The research in this study uses the Research and Development (R&D) research method. The development model employed in this research is the ADDIE development model. The ADDIE development model consists of analysis, design, development, implementation, and evaluation (ADDIE) (Lee & Owens, 2004). This method was chosen because it can explain the students' competence before and after using the learning media (Kurnia Yunita et al., 2022). The development procedures are as follows :

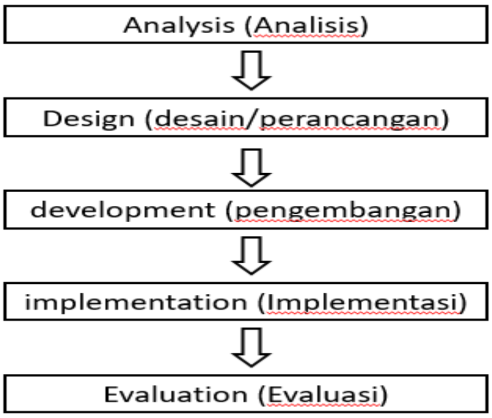

Figure 1. Research procedures

A. Analysis

The first stage in the ADDIE development method is problem potential analysis. In this stage, researchers conduct an analysis of the issues in SMK Nurul Barqi's Electrical Installation Engineering (TITL) department related to teaching and learning media. This analysis includes:

a. Curriculum and Content Analysis

Researchers analyze the school curriculum, which encompasses core competencies, basic competencies, and competency achievement indicators. Additionally, researchers also analyze the teaching materials delivered to students. This analysis is aimed at determining the alignment between the curriculum and teaching materials so that appropriate instructional media can be developed, which will aid in delivering the teaching content.

b. Student Competency Analysis

This analysis is conducted to understand the initial competency levels of students in the school. Through this analysis, the researcher hopes to map out the competencies of students and their difficulties in learning, which can be improved through the development of instructional media.

c. Learning Media Analysis

Researchers analyze the instructional media that are already available at SMK. Subsequently, an analysis is conducted to determine the compatibility of these media with the curriculum and teaching materials. Furthermore, an analysis is also performed to evaluate the effectiveness of these media in enhancing student competency, as evidenced by the students' academic performance.

d. Design

Design is the planning process that involves imagining, analyzing, and creating to produce an acceptable product. The product design is intended to provide a detailed framework for the product to be developed. The product's design details include specifications, components, benefits, and visual design. In this research, a product design is created with the following framework:

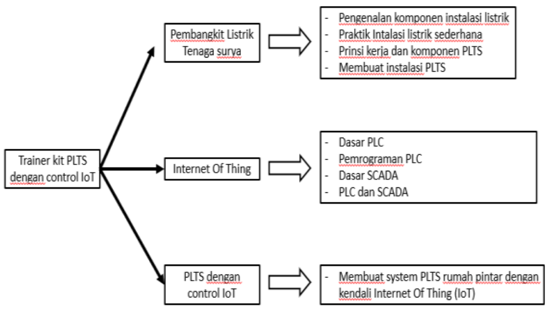

Figure 2. product designDevelopment

This stage involves materializing a product after it has been previously designed in the design stage. During this stage, the process of creating the trainer framework, component assembly, trainer testing, and job sheet creation will take place. Once the trainer is successfully created, it will undergo testing and revisions by media experts.

B. Product Implementation

During this stage, the trainer is directly implemented for students during their learning process. Testing related to the improvement of student competencies before and after using the trainer is also conducted.

a. Product Testing

Product testing is carried out to assess the impact on respondents before and after using the product (Junaidi & Suprianto, 2020). Product testing is performed on students from the 11th grade of the Electrical Installation Engineering Department (TITL) at SMK Nurul Barqi-Semarang. This testing is conducted after the product has been validated by experts. The testing is done using the pre-experimental design method, specifically the One Group Pretest-Posttest.

b. Test Design

The One Group Pretest-Posttest design is used as the testing method for the development of this trainer. In this test, a pre-test is conducted before any treatment is given to the test subjects. Using this method, the responses of the subjects before and after the treatment can be observed (Rukminingsih et al., 2020). The research with the One Group Pretest-Posttest design is depicted as follows:

O1 X O2

Explanation:
O1 = Pretest score (before using the media)
O2 = Posttest score (after using the media)
X = Treatment on the samples

c. Implementation Subjects

The participants used for the experiment are students from the 11th-grade Electrical Installation Engineering Department (TITL) at SMK Nurul Barqi-Semarang. SMK Nurul Barqi Semarang was chosen as the testing location due to its suitable department and infrastructure. The 11th-grade TITL class was selected because it includes the basic competence of building lighting installation control systems (smart buildings).

d. Data Type

The data type in the development of this trainer is quantitative data. Quantitative data is data that describes information or facts in numerical form. The data for this research was obtained from several sources, namely:

A. Data from subject matter experts

Data from subject matter experts assess the product's feasibility in terms of the quality of trainer materials, including lighting installation materials, PLTS (Photovoltaic Solar Panels) installation, PLC (Programmable Logic Controller), HMI (Human Machine Interface), and SCADA (Supervisory Control and Data Acquisition).

B. Data from media experts

Data from media experts evaluate the product's quality in terms of ease of media usage, relevance to teaching materials, delivery of materials, alignment with the syllabus, and its relevance to student comprehension.

C. Data from students

Data from students consist of pretests and posttests administered to students before using the trainer, during its use, and after using the trainer. This data will be analyzed to determine the effectiveness of using the trainer in terms of students' understanding before and after using it.

e. Data Collection Instruments

Data collection instruments refer to tools used in the data collection process. The validity of the instruments is directly related to the accuracy of the collected data. Therefore, appropriate instruments are needed for the research:

1. Questionnaire

A questionnaire is a sheet containing assessments, statements, or comments (Fauzan & Mulyana, 2022). In assessing the quality of media to be used, a feasibility test is conducted first. The feasibility test is conducted by 4 media experts, consisting of 2 subject matter experts and 2 media experts.

2. Test Instruments

Test instruments are used to collect the necessary data in the research. Examinations or tests are measurement tools used to gather information about something. Previously approved and validated teaching media are then tested for use in the classroom. Test instruments are used to assess the students' learning outcomes. The test scheme in this research consists of multiple-choice questions and is conducted twice. The first test is done before using the trainer, and the second test is done after using the trainer developed. By conducting these two tests, data is obtained that can be used to measure the effectiveness of the developed trainer.

f. Data Analysis Techniques

Quantitative data analysis is the analysis of data that is conducted after respondent data has been collected in sample/population format. This data analysis utilizes quantitative descriptive methods to analyze the results of questionnaire data obtained from expert evaluations and student learning achievement tests. Quantitative descriptive data is used because this research and development aims to measure the effectiveness of the Solar Power Plant (PLTS) trainer development with IoT control, for which questionnaires are used as the data instrument. The following is the data analysis used:

Table 2. Data analysis techniques

Test Type	Function	Formula
Feasibility test	Testing how ready and feasible a media is before implementing it	$P = \frac{\Sigma n}{\Sigma N} \times 100\%$
Validity	Testing the validity of a questionnaire	$Ypbis = \frac{\mathrm{Mp} - \mathrm{Mt}}{\mathrm{St}} \sqrt{\frac{p}{q}}$
Reliability	Testing the consistency of an instrument	$r11 = \left(\frac{k}{k-1}\right) \left(1 - \frac{M(k-M}{kVt}\right)$
Difficulty Level	Measuring the level of difficulty of a question.	$P = \frac{B}{Jx}$
Normality test	Knowing the distribution of data variables	$\mathrm{KD} = 1{,}36 \frac{\sqrt{n1}+n2}{n1n2}$
Homogeneity test	Testing a group of respondents whether they belong to the same population	$F = \frac{Max\ Varians}{Max\ Varians}$
t-test	Testing the partial significant influence of the independent variable on the dependent variable.	$t = \frac{Md}{\sqrt{\frac{\sum X^2 d}{N(N-1)}}}$
Normalized gain test	Measuring the increase in students' cognitive learning skills and outcomes before and after learning	$\text{N-Gain} = \frac{Skor\ Posttest - Skor\ Pretest}{Skor\ Maksimum - Skor\ Minimum}$

Evaluation

At this stage, all the data collected in each of the above stages is analyzed and summarized. These conclusions are aimed at identifying the strengths and weaknesses of the product so that it can be improved.

RESULT AND DISCUSSION

A. Learning Media Design

1) Analysis

The initial stage in the development of learning media is conducting analysis. The analysis is carried out on students majoring in Electrical Power Installation Engineering (TITL) at SMK Nurul Barqi Semarang. This analysis activity includes at least three aspects: curriculum and content analysis, student competency analysis, and learning media analysis. From the researcher's observations, a problem was identified in the curriculum, specifically in the Basic Competency (KD) related to building lighting control systems (smart building). This requires teachers to teach this competency to students. However, in practice, students' competency in this area is relatively low, as indicated by their low scores on daily assessments related to this KD.

2) Design

The next step in the development of media is the design phase. After identifying the problem that there is a need for learning media to support the KD of building lighting control system development (smart building), the researcher chose a learning media in the form of a trainer. This choice is based on the trainer's ability to replicate real working objects into a simple device. At this stage, the researcher creates an initial sketch of the trainer's design.

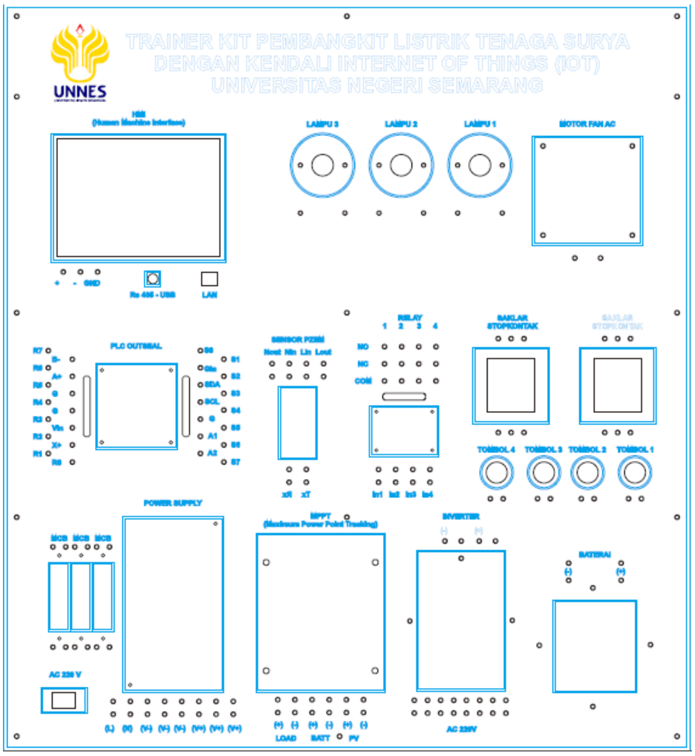

Figure 3. Trainer kit sketch design

In that design, the researcher integrated a Solar Power Generator (PLTS), PLC Control, HMI Interface, and SCADA/IoT system into one trainer. The trainer is also equipped with banana plug sockets to facilitate students in assembling components.

3) Development

In this stage, the design that has been created is implemented into a physical form. The trainer takes the form of a stand with supports made of 3cm x 3cm hollow steel. The base of the trainer is made of acrylic cut by a cutting machine. The trainer is also equipped with a stand to support the PLTS on top, which can be detached for outdoor use in building lighting control systems (smart building installations).

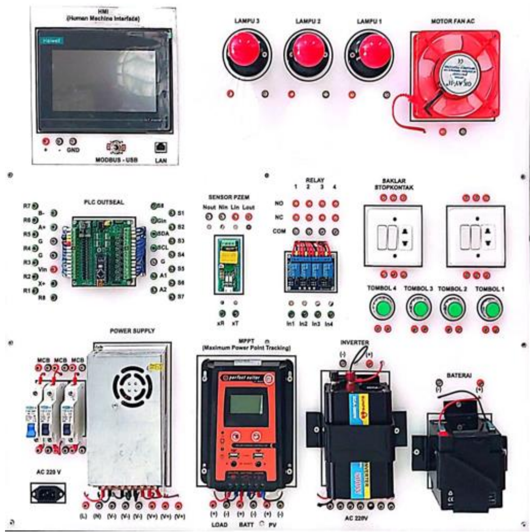

Figure 4. Trainer kit front view

The design and development were tested by media experts and material experts. Based on expert assessments, the media obtained a percentage of 87% and was categorized as very feasible.

Table 3. Media expert test results

No	Media Expert	score
1.	Media Expert 1	92
2.	Media Expert 2	82
total score		174
Max total score		200
Percentage %		87%
Category		Very worthy

After being reviewed by media experts, material experts then conducted the material evaluation. In that evaluation, a presentation score of 88% was obtained and categorized as very suitable.

Table 4. Material expert test results

No	Expert matter 1	score
1.	Expert matter 1	80
2.	Expert matter 2	95
total score		175
Max total score		200
Percentage %		88%
Category		Very worthy

B. Effectiveness of Learning Media

1. Validity Test of Test Items

In this research, the validity test was conducted on the student test instrument. The validity test in this research was performed on 30 respondents with 40 test items. The researcher set a significance level of 5% or 0.005 in the measurement of r_calculation > r_table. From the validity test results of 30 students and 40 test items, the r_table value obtained was 0.361. Thus, from the equation r_calculation > r_table, it was found that 30 items were valid, and 10 items were not valid. Out of this test, 30 items were selected as research instruments, and 10 items were not used.

2. Reliability Test

In this research, the KR-20 reliability test was used. KR-20 was used because the research instrument consisted of test items, and the data generated were either correct or incorrect (Dewi et al., 2020). In this research, a reliability value of 0.87 was obtained. According to the criteria for reliability coefficients, 0.87 < KR-20 < 1.00 is classified as very high reliability. Therefore, the instrument in this research is considered highly reliable.

3. Test of Question Difficulty Level

This test is aimed at classifying the difficulty levels of the questions. Out of the 30 valid questions, after analysis, it was found that 3 questions were categorized as difficult, 21 questions were categorized as moderate, and 6 questions were categorized as easy. This classification was based on the difficulty index.

4. Normality Test

The normality test was conducted to determine whether the data followed a normal distribution or not. In this research, the Kolmogorov-Smirnov (K-S) test was used for the normality test. Based on the K-S equation, test results of (0.131) and (0.242) were obtained. Both of these values were > 0.05. Therefore, it can be concluded that the residuals are normally distributed.

5. Homogeneity Test

The homogeneity test was conducted to determine whether the sample data came from the same variance or not. Based on the researcher's calculations, the homogeneity value was found to be 1.38 < 1.86. From this value, it can be concluded that the data is homogeneous.

6. t-Test

The t-test was conducted to test the hypotheses related to the influence of each variable. In this research, the average pre-test score was 58.4, and the average post-test score was 76.16. Then, the t-value was calculated to be -7.79, and the t-table value was 2.00. Thus, it can be concluded that -7.79 < 2.00 < 7.79, indicating an influence of using the trainer on improving students' competence.

7. N-Gain Test

The N-Gain test was conducted to determine the difference between pre-test (before treatment) and post-test (after treatment) scores. Based on the test results, the average N-Gain value was found to be 0.89. This value falls into the "high" category.

C. Evaluation

In this research, a solar power trainer kit with Internet of Things (IoT) control has been developed. The test results indicate that this trainer is suitable for use as a learning media. However, from a series of tests conducted by the researcher, there are still some shortcomings that need to be addressed for future development, including:

1. The I/O trainer design should be expanded to introduce various types of I/O to students.
2. The I/O trainer design should be expanded to introduce various types of I/O to students.
3. The usage of the trainer kit should be made simpler and safer with pre-installed source ports to prevent misconnections.
4. Implementation for students should be done after they have received PLC, solar power, and electrical installation materials to make it easier for them to understand the trainer's content.

Discussion

The final product of the solar power generation trainer kit with Internet of Things (IoT) control is a trainer-shaped learning medium with a stand concept. This trainer is equipped with a practical guidebook and banana sockets, allowing students to easily connect and disconnect cables according to the instructions in the practical guidebook. Based on the identified problem, in the basic competency of building lighting control systems (smart buildings), students were receiving low daily test scores. Further analysis revealed that one of the reasons for this was the lack of learning resources related to this competency. Therefore, in response to this issue, the researcher developed a solar power generation trainer kit with IoT control, based on PLC and SCADA control systems, to align with the learning needs of solar power generation with IoT control.

The development of a trainer requires a series of testing processes, including feasibility testing. According to Sugiyono, feasibility testing is conducted to assess whether a developed product is ready for implementation or not. Therefore, a good product must undergo feasibility testing first. In this research, feasibility testing was conducted by media experts' validators, followed by content experts' validators. Based on the assessment results, a feasibility score of 87% was obtained for media and 88% for content, categorizing the developed media as highly suitable for implementation.

After the product was deemed feasible by the experts, it was tested to determine its impact on student learning outcomes. In this testing, N-Gain testing was conducted by comparing students' learning outcomes before and after using the product. After the N-Gain test, a score of 0.89, categorized as high, was obtained, indicating that the use of the product had a significant impact on student learning outcomes.

This discussion aligns with previous research. A related study on the development of a solar power generation trainer design has been conducted (Lawal et al., 2019). In that study, a solar power generation trainer capable of simulating changes in PV voltage and current based on sunlight intensity was developed. Sunlight intensity was simulated using adjustable lighting angles. Through this mechanism, it was expected that students could analyze and calculate the relationship between sunlight and the voltage and current produced. The trainer received a label of suitability for use as a learning medium. The similarity between the researcher's study and Lawal's study is that both developed solar power generation trainer kits that could monitor voltage and current, but this study used IoT for monitoring and control.

Another study conducted by Wardiyanto & Yundra (2019) focused on developing an Arduino-based microcontroller integrated with IoT concepts in a trainer kit. Trials were conducted to measure its validity, ease of use, and effectiveness. The trial results showed a validity rate of around 91.67%, ease of use rate of approximately 81.25%, and effectiveness rate of about 82.1286%. During the testing phase involving 28 students, it was found that the average student scores increased after using this trainer kit. Therefore, it was concluded that the use of the trainer kit could enhance students' competence. The similarity between this study and Wardiyanto & Yundra's study is the use of IoT as the control and monitoring system, but the difference lies in this study's use of PLC and SCADA controllers, which are more suitable for TITL students.

Based on the explanations provided, it can be concluded that the solar power generation trainer kit with IoT control developed in this research is relevant to previous studies, deemed feasible, and effective for use. The trainer's ease of use is enhanced by the plug-and-play mechanism, facilitated by the inclusion of banana sockets, making it suitable for practical learning.

CONCLUSION

The solar power generation trainer kit with Internet of Things (IoT) control has been successfully developed. The trainer is constructed with a standard model and features a panel made of acrylic to house the components. Based on the testing results conducted by media experts and subject matter experts, the trainer is categorized as highly suitable, with a media expert score of 87% and a subject matter expert score of 88%. The testing of the solar power generation trainer kit with IoT control yielded an average N-Gain score of 0.89, falling into the high category. Therefore, it can be concluded that this trainer is highly effective in enhancing the competencies of students in building lighting control system installations (smart buildings).

REFERENCES

Adam, M. A., Anifa, L., & Nurhayati. (2022). Pengembangan Trainer Kit Mikrokontroler Nodemcu Esp32 Berbasis Iot Sebagai Media Pembelajaran Pada Mata Pelajaran Pemrograman, Mikroprosesor, Dan Mikrokontroler Di SMK NEGERI 1 SIDOARJO. *Jurnal Pendidikan Teknik Elektro*, *11*.

Afrizal, M. A., & Suprianto, B. (2018). *Rancang Bangun Rumah Pintar Berbasis Iot (Internet Of Things) Sebagai Media Pembelajaran Pada Mata Pelajaran Pemrograman, Mikroprosesor, Dan Mikrokontroller di SMKN2 SURABAYA*.

Anggraini, L., 1∗, P., Qudus, N., & Wahyuningsih, S. E. (2022). Journal of Vocational Career Education Development Oof Audio-Visual Learning Media to Increase the Ability of Makeup Skill Demonstration. *JVCE*, *7*(2), 32–40. https://journal.unnes.ac.id/nju/index.php/jvce

Aqsha, I., Nur, H., & Lamasitudju, C. (2020). PENGEMBANGAN MODEL PEMBELAJARAN PRAKTIK PENGELASAN BERBASIS KEWIRAUSAHAAN DI SMK NEGERI DI KABUPATEN BULUKUMBA. *JURNAL MEDIA ELEKTRIK*, *17*(2), 2721–9100.

Celestino Doanwilmon, P., & Aswardi. (2020). Pengembangan Media Pembelajaran Mikrokontroler Berbasis Trainer Pada Jurusan Teknik Elektro Fakultas Teknik Universitas Negeri Padang. *JTEV (Jurnal Teknik Elektro Dan Vokasional)*, *6*(1), 280–286. http://ejournal.unp.ac.id/index.php/jtev/indexJTEV

Fauzan, R., & Mulyana, D. (2022). Pengembangan Trainer Conveyor Menggunakan Outseal Plc Pada Mata Pelajaran Instalasi Motor Listrik. *JEVTE: Journal of Electrical Vocational Teacher Education*, *2*(2).

Junaidi, A., & Suprianto, B. (2020). Pengembangan Trainer Dan Job Sheet Programmable Logic Controller (Plc) Pada Mata Pelajaran Instalasi Motor Listrik Di SMK SEMEN GRESIK. *Jurnal Pendidikan Teknik Elektro*, 315–324.

Kurnia Yunita, D., Widjanarko, D., Syamwil, R., Babalan -Prawoto, J., Undaan, K., & Kudus, K. (2022). Journal of Vocational Career Education Development of Illustrator Software Assisted Clothes Design Learning E-Module for Vocational School Fashion Design Program. *JVCE*, *7*(2), 10–19. https://journal.unnes.ac.id/nju/index.php/jvce

Lee, W. W., & Owens, D. L. (2004). *Multimedia-Based Instructional Design* (2nd ed.). Pfeiffer.

Noor Jannah, R., Khumaedi, M., & Widjanarko, D. (n.d.). *Journal of Vocational Career Education Developing Audio-Visual Learning Media in the Competency of Making Robe Patterns Based on the Design*. https://journal.unnes.ac.id/nju/index.php/jvce

Yadav, G., & Paul, K. (2021). Architecture and security of SCADA systems: A review. In *International Journal of Critical Infrastructure Protection* (Vol. 34). Elsevier B.V. https://doi.org/10.1016/j.ijcip.2021.100433

Yuliarsih, A., Ruslan, & Suhardi Rahman, E. (2022). Pengembangan Trainer Instalasi Listrik 1 Pada Jurusan Pendidikan Teknik Elektro Fakultas Tektik Universitas Negeri Makassar. *Jurnal MEDIA ELEKTRIK*, *19*(3), 2721–9100.